United States
Department of
Agriculture

Department of the
Interior

Forest Service

**Equipment
Development
Center**

Missoula, MT

Vegetative Rehabilitation & Equipment Workshop

39th Annual Report
Salt Lake City, Utah
February 10 & 11, 1985

December 1985
2200—Range
8522 2801

Vegetative Rehabilitation & Equipment Workshop

39th Annual Report
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PARTICIPANTS

U.S. Department of Agriculture
U.S. Department of the Interior
State and County Organizations
State Wildlife Agencies
Industry Representatives (Chemical, Equipment, Mining, Seed)
Educational Institutions
Ranchers
Foreign Countries

December 1985

United States Department of Agriculture | Forest Service | WO

March 16, 1985

Dear VREW Participants:

Approximately 250 people participated in the 1985 workshop in Salt Lake City. Most people that I talked to felt that it was a very good session. Steering Committee members heard numerous favorable comments on the papers presented, and the overall program objective of technology transfer.

Special thanks go to Dick Page for his assistance on arrangements for room and equipment; and to Steve Monsen for his outstanding work in developing the agenda, particularly the plant materials segment.

Joe Pechanec, the first chairman, was in attendance and spoke briefly on the accomplishments of the workshop since its inception in 1946.

One of the highlights of the workshop was the plant materials presentation. Great progress is being made in the development of new or improved plant materials, particularly shrub species. A number of good papers were presented, and are reproduced in this report. Anyone interested in specific information on the characteristics or availability of new releases should contact plant materials workgroup chairman Wendall Oaks at (505) 856-4684.

The VREW budget for development of new equipment is going to be significantly reduced for the next few years. We will concentrate on making users aware of the equipment, materials, and technology already available to aid in range and disturbed land reclamation.

One of the efforts in this area in 1985 will be the preparation and distribution of a guide for selecting available wind-powered water pumping equipment and a list of suppliers. Also, we are in the early stages of work to develop a standard guide, or catalog of specifications, for structural range improvements such as fences, cattleguards, spring developments, etc. We envision a package that would be usable and useful to Federal and State agencies and the private sector.

The 1986 workshop will be held in Orlando, Florida on February 9 and 10, 1986. Plan to be there. If you would like to make a presentation, or would like specific information presented, please let me know.

Sincerely,

Randall R. Hall

RANDALL R. HALL
Chairman, Vegetative Rehabilitation
and Equipment Workshop

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Monday—Feb. 11

Remarks

Joseph F. Pechanec, *First Chairman of VREW, 1946-1951*

This year is an anniversary, not only for the Society for Range Management, but for VREW and its predecessor, the Reseeding Equipment Development Committee. In July 1945 representatives of western Forest Service regions and stations, together with Washington Office representatives, meeting in Utah recommended major emphasis on testing, adapting, and designing equipment to carry out range reseeding work. They also recommended that the skills of the Equipment Development Center at Portland, Oregon, be brought to bear on this important task. A committee was established that year and some committee work begun. So this becomes your 40th anniversary.

In a paper presented at your San Antonio meeting in 1978 W.R. Chapline gave an excellent review of events leading up to the establishment of the Committee. Then in 1982 your group published a complete history of activities and accomplishments of VREW (1946-1981). There are only a couple items I might add to the coverage given by these two reports.

At the time the Committee was established considerable information had already been compiled on both mechanical and other sagebrush control methods. A major effort during World War II to increase production of food and fiber lent urgency to a major push encouraging use of range improvement methods that provided early returns. Seeding of depleted sagebrush-type lands had been proven to provide early returns by both research and administrative pilot tests. Sagebrush control was essential for early and successful seeding establishment. Sagebrush control was also essential for rapid range recovery where seeding was not necessary.

Considerable information was available from agencies and individuals who had been doing range reseeding work and sagebrush control work. Assembly of information on types of equipment used and suitability began in 1942 by the Intermountain Station and an evaluation was published in 1944 as Intermountain Station Paper No. 10. Thus, the Committee had a considerable head start on equipment for sagebrush control, which made up a major portion of our early work.

Joint field review by engineers of the Equipment Lab and range staff or research men was an early pattern for work of the Committee. We found that engineering experience was almost wholly with road, logging and fire equipment, terrain, conditions and objectives. We needed to establish a feel on their part for range conditions under which equipment was being used, available equipment, and results being sought. Ted Flynn and I spent several weeks in 1946 traveling to range reseeding jobs in western regions. It was wonderful to travel with Ted and I know I learned as much as he, and in any event, a profitable pattern developed of pooling the different viewpoints in all steps of the program.

It must not be left unsaid that the magnitude and diversity of the task facing VREW and the early Committee stimulated a profusion of ideas on how to do the job better. Countless people contributed throughout all phases. Would-be investors sprouted up all over the place. These were winnowed out by the Committee or Working Group and the history is testimony to the productivity.

Thank you for inviting me to attend and say a few words. I wish you well in the rest of your meeting here. I hope that some day in the not too distance future that it may again be possible to attend your VREW meeting.

Keynote Address

Development of Plants Which Will Provide a "Diverse, Effective, and Permanent" Vegetative Cover

Howard C. Stutz, *Brigham Young University, Provo, UT*

Regulations of the Office of Surface Mining require revegetation of mined lands with a vegetative cover that is "diverse, effective and permanent" (30CFR 816.111). The *diverse* component of this regulation is pivotal in that the other attributes can, in no way, be obtained without it. Although diversity is usually interpreted to mean species diversity, its significance in reclamation is far broader, with implications at four distinct levels.

1. At the level of individual organisms.
2. Within species.
3. Within communities.
4. Within associations.

1. Diversity at the level of individual organisms is often referred to as plasticity. Highly plastic plants can adjust to environmental fluctuations and are, therefore, more common in unpredictable environments. Long-term exposure to stable environments result in selection for plants having low plasticity. Because disturbed sites such as mined lands are highly unstable, plants having abundant plasticity are more likely to be successful on them than those that have been selected for narrow, restricted ecological niches. The most likely source for successful introductions on disturbed sites are, therefore, collections derived from rapidly changing, unstable habitats.

2. Within-species diversity results from genetic differences between plants. Such genetic flexibility is also reduced by natural selection in stable, predictable habitats. It is therefore highest in plants which occupy rapidly changing sites. Without abundant genetic flexibility, organisms cannot occupy the numerous microenvironments that characterize newly disturbed sites nor can they survive the ecological changes which follow.

Since hybridization provides the greatest amount of genetic flexibility, in the shortest possible time, hybrid products are, by far, the best candidates for use in reclamation efforts. Narrow-based genotypes, such as those derived from single-source collections or from certified seed developed by intense selection, are the worst possible choices.

3. Diversity within communities is a function of species richness. New habitats are often initially saturated by monocultures of species which get there "firstest with the mostest." This is true of many of the valleys of western North America, which became suddenly available 10-12,000 years ago when the Pleistocene lakes dried up. Vast acreages are now occupied by monocultures of species such as winterfat (*Ceratoides lanata*), greasewood (*Sarcobatus vermiculatus*), saltsage (*Atriplex tridentata*), gray molly (*Kochia americana*) or shadscale (*Atriplex confertifolia*). In time, successional changes can be expected to modify and enrich these populations. Elsewhere, these same species are components of species-rich communities.

Reclamation of disturbed lands, however, need not await the tediously slow succession as it occurs in nature. By introducing rich mixtures, species-rich communities can be attained "instantly." Not just any concoction will have equal success, however, because some combinations of species are more compatible than others. Fourwing saltbush (*Atriplex canescens*), for instance, may do well with *Grayia spinosa* but not with *Grayia brandegei*, or Galleta grass (*Hilaria jamesii*) may do well with *Artemisia bigelovii* but not with *Artemisia tripartita*. Also, southern species will not likely succeed at northern latitudes nor will sand-loving species likely succeed on heavy clay soils. It is also unlikely that anything but wind-pollinated species will be able to reproduce and appropriate pollinators for other species are almost certainly initially absent. But beyond such conspicuous judgments, mixtures of species, each of which has sufficient between-species and within-species heterogeneity to permit a good deal of failure, provide the most promising prospects.

4. Diversity within associations stems from diversity at all other levels. Rich associations consist of many kinds of organisms, including plants, microorganisms, and animals, all tied together in functional food webs and reproductive opportunities.

In some instances, attaining adequate association-diversity will require erecting rock piles, developing ponds, treating soils with innocula or introducing livestock. It must always include extensive plant diversity in order to provide a variety of root systems, several canopy heights and densities, several seasons of flowering and seed production, both evergreen and deciduous habitats, a range and a variety of palatabilities to herbivores, etc. In such associations, component species can perpetually contribute and continually evolve to become evermore productive. Such associations in nature are the most attractive, the most dynamically stable, and the most productive. They can be achieved on disturbed lands, only if the gates to diversity are opened wide at all levels.

Panel Discussion

Development of Conservation Plant Varieties

H. Wayne Everett and Wendall R. Oaks,
Soil Conservation Service

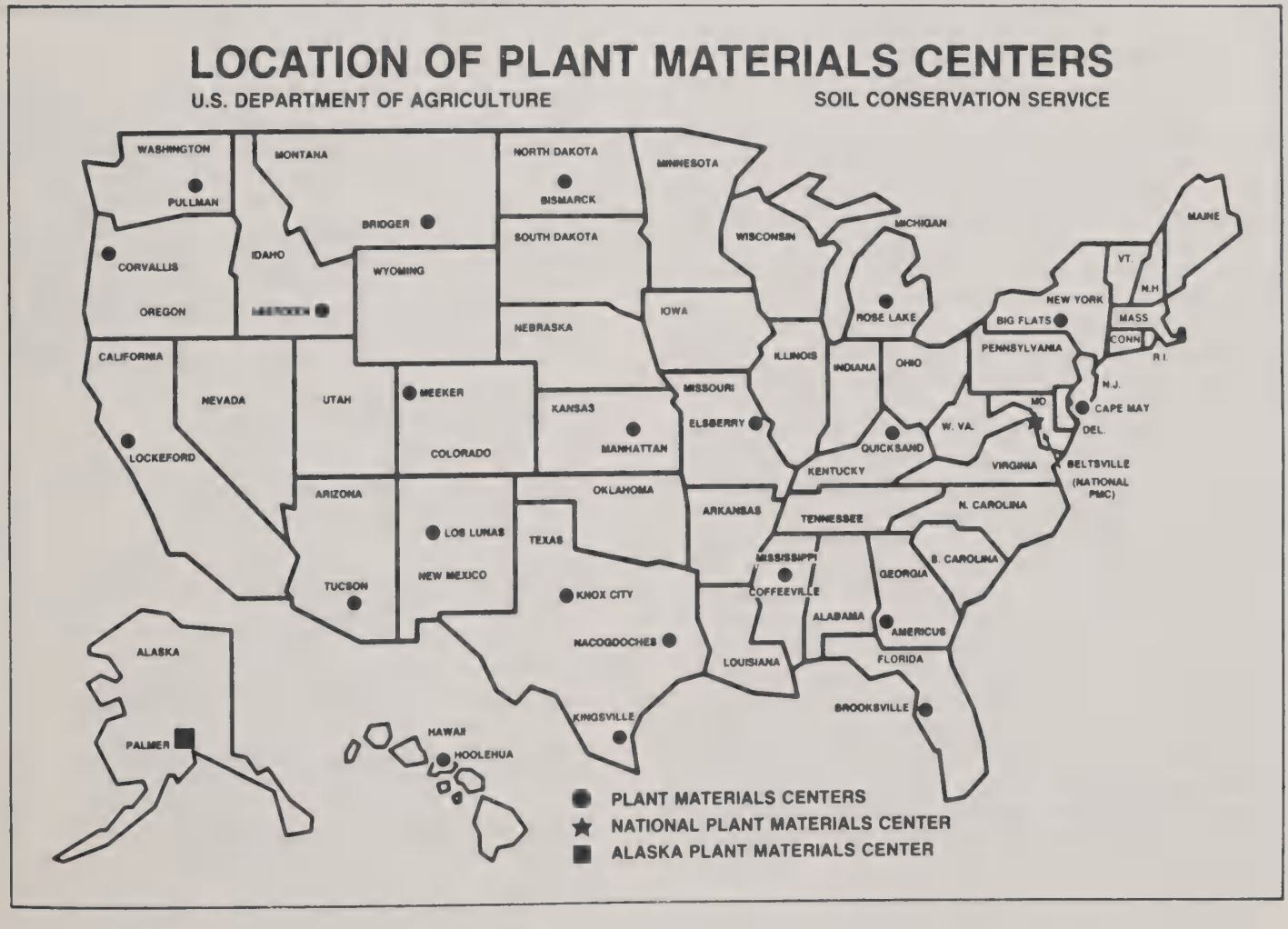
Summary

SCS operates a coordinated network of 24 plant materials centers in the United States to assemble, evaluate, select, cooperatively release, and provide for the commercial increase of native and introduced plants for the conservation and improvement of soil, water, and related resources. Standardized procedures have been developed and are being used for this comparative plant testing program. Evaluation data can be retrieved from an automated data processing system through standardized or user-designed reports. Over 150 SCS-released varieties of conservation plants are available commercially for range, pasture, and other land improvement to reduce sediment movement and improve wildlife habitat. These improved plants can also solve other erosion problems, including the reclamation of surface mined land, roadside development, and sand dune and shoreline stabilization. A number of new varieties for use in grassland plantings are now available.

Introduction

Since the 1930's the USDA Soil Conservation Service (SCS), has operated a coordinated network of plant materials centers to evaluate, select, release, and introduce into commerce, new plant varieties for use in the conservation of soil, water, and related resources. There are now 24 plant materials centers strategically located in the United States, each serving two or more major land resource areas[1] of similar soils, climate, and conservation problems. The centers are operated by SCS or receive some management and guidance from SCS personnel.

A short review of the procedures in plant evaluation and release and comments on a number of new plant varieties of interest to our rangeland-oriented friends are two objectives of this presentation.



[1]U.S. Department of Agriculture. 1981. Land resource regions and major land resource areas of the United States. Agriculture Handbook 296.

Procedures

Operation of any plant materials center begins with a documentation of the conservation problems, their scope, and priority. SCS personnel at the State and county levels identify the conservation problems and priorities on which the center will direct all plant assembly, evaluation, selection, and release of superior varieties. Representatives of other agencies and soil conservation districts assist. Improved plants are needed for such problems as range and pasture improvement, grassland waterways, gully stabilization, roadside development, streambank protection, reclamation of mined land, dune and shoreline stabilization, cover crops, and wildlife food and cover.

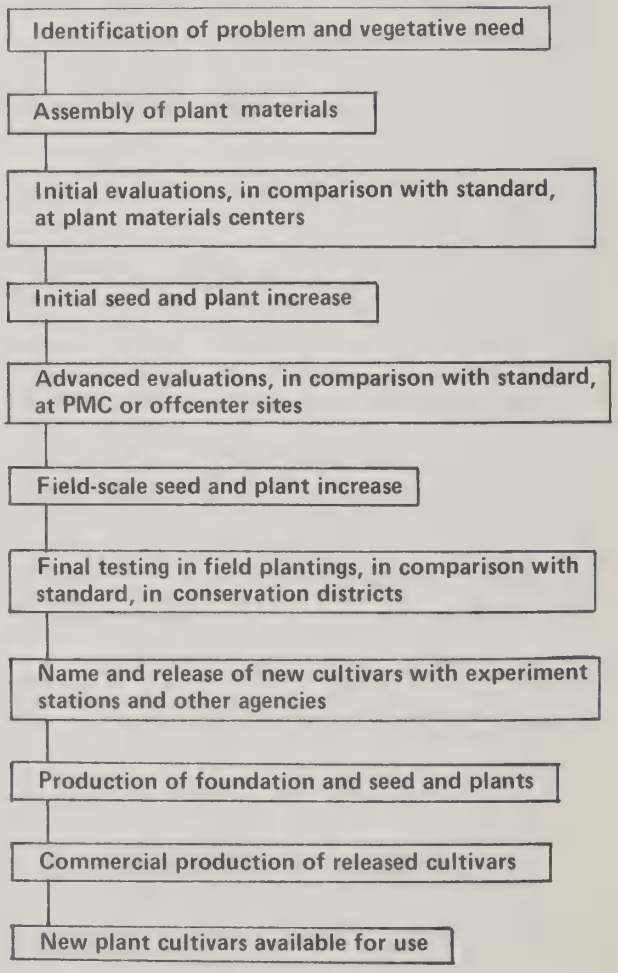
Plant materials centers assemble seed or plants from local native collections, from plant introduction stations, from private seed or plant companies or reseachers, and from foreign collection trips by other agencies. Assembled plant materials are grown in rows or blocks, and performance data are collected and tabulated for 1 to 10 years. Comparisons are made using available commercial strains or varieties. Data on vigor; production and quality of forage, seed or biomass; insect and disease resistance; adaptation; and other plant characteristics are collected and analyzed. This plant materials work is conducted in cooperation with State agricultural experiment stations and Federal or State agencies. Selection of superior accessions or ecotypes is made at the plant center.

These accessions are increased at the center (initial seed/plant increase) and evaluated on controlled sites away from the center to determine adaptation and performance. These field evaluation plantings are often done on State experiment station sites or on land under the control of other agencies. Again, available commercial strains or varieties are evaluated as a standard. Data are recorded for 1 to 5 years and selection of a best performance accession is made. The selected accession is increased at the plant materials center (field scale increase) for a final evaluation step—field plantings.

The unique and most effective step in the development and introduction of a new conservation plant is field plantings on the farms or ranches of soil conservation district cooperators or on the land of other cooperators such as State departments of natural resources, fish and game agencies, or State highway departments. The field planting step is the final check on the adaptation and performance of a potential conservation plant under actual-use conditions. It is a direct comparison of the accession being tested versus the plant currently recommended for a specific site, soil, and conservation problem. SCS conservationists, State experiment stations and other agency personnel, farmers, and ranchers collect periodic evaluation data to determine specific adaptation and performance on the problem site in the field. Based upon successful evaluation in field plantings, a new plant may be recommended for release as a new variety.

SCS, agricultural experiment stations, and other cooperating agencies assemble the plant evaluation data, name the plant, prepare a release notice for the new plant, and jointly recommend the release as a new variety. The originating agency assumes responsibility for the maintenance of breeder seed or plants. Foundation seed or plants are distributed to commercial seed or plant growers through a crop improvement association or foundation seed project associated with the State experiment station. SCS shares and exchanges seed or plants with the State experiment station and may distribute them through soil conservation districts to qualified local growers for the production of certified seed or plants. SCS and/or the State experiment station carry out demonstration plantings and distribute information to encourage purchase and use of new variety. SCS continually amends its standards and specifications to include new varieties, thereby encouraging their use for helping solve local conservation problems.

SCS PLANT MATERIALS PROGRAM



SCS has strengthened the evaluation process by using more statistical evaluation of the performance of tested plants, by increasing the number of cooperative evaluations by agriculture experiment stations or other Federal and State agencies, by developing more accurate field evaluation of potential new varieties before release, and by implementing a data processing system to input and retrieve evaluation data. [2,3]

Results—Recent Variety Releases

Most of the varieties released since 1943 have been grasses, legumes, and forbs for use in grassland conservation plantings, but several shrub and tree varieties have been released for windbreaks and wildlife food and cover plantings.[4] Over 150 are commercially available.[5] A few examples of recent cooperatively released varieties of grass, legumes, and forbs include:

'Hachita' blue grama, a warm season native bunchgrass, was released for range and critical area seedings in the Southwest United States.

Three varieties 'Arriba,' 'Barton,' and 'Rosana' western wheatgrasses, native cool-season sod-forming grass species, were released in the 1970's for use in range seedings and critical area plantings in the Midwest and Western United States. All are commercially available.

Several varieties of Atriplex species have been released for use in range seedings, critical area stabilization, and wildlife food and plant cover plantings. 'Marana' and 'Wytana' fourwing saltbush, 'Corto' Australian saltbush, and 'Casa' quailbush, are now available for use in the various parts of the Western United States.

Maximillian sunflower is a tall native perennial forb useful for range seeding mixtures and plantings in much of the southern Great Plains. The varieties 'Aztec' and 'Prairie Gold' are available commercially. Several other forbs have been released since 1970 for use in mixtures for rangeland reseeding and in critical area stabilization. These include 'Kaneb' purple prairie-clover, 'Sunglow' grayhead prairie coneflower, 'Nekan' pitchersage, 'Eureka' thickspike gayfeather, and 'Bandera' Rocky Mountain penstemon.

SCS has recently been concentrating on native plant evaluation and release, but introduced species, such as the limpograsses, a number of lovegrasses, buffelgrass, and wheatgrass often play an important role in helping solve soil, water, and related resource conservation problems because they are adapted to and productive on our grasslands in the United States.[6]

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[2]U.S. Department of Agriculture. 1984. National plant materials manual. Soil Conserv. Serv.

[3]U.S. Department of Agriculture. 1984. (Unpublished draft). Ecological sciences automatic data processing user handbook. Soil Conserv. Serv.

[4]U.S. Department of Agriculture. 1983. Improved plant materials comparatively released by SCS through 1983. Soil Conserv. Serv.

[5]U.S. Department of Agriculture. 1980. Commercial production of SCS released plant varieties—1979 production, retail value, and potential acres to be treated. Soil Conserv. Serv.

[6]U.S. Department of Agriculture. 1979. Plant materials for conservation. Program aid 1219. Soil Conserv. Serv.

Notes on Some 1984 Conservation Plant Releases of Interest to Range-Oriented Personnel From the SCS Cooperative Plant Materials Program

'Rincon' fourwing saltbush — cooperative release with USFS and several SAES's; third variety of species, but first adapted intermountain area; several seed orchards established in 1983; PI 478841, native to New Mexico.

'Immigrant' forage kochia — cooperative release with USFS and several SAES's 314929 from USSR; excellent range forage for cheatgrass or halogeton ranges.

'Hycrest' crested wheatgrass — cooperative release with ARS and Utah Agricultural Experiment Station (AES); substantially greater drought tolerance and establishment on arid rangelands; could replace 'Nordan' and 'Fairway' as the standard; cross between *desertorum* and *cristatum*; multi-PI line parentage.

'Bozoisky-Select' Russian wildrye -- cooperative release with Utah ARS and Montana AES; much greater seedling vigor than 'Vinall' and other varieties, plus greater production; should be very successful.

'San Luis' slender wheatgrass — selected by Meeker (Colorado PMC); released by SCS, USFS, and three State agricultural experiment stations for high altitude seedings; longer lived than standard varieties or common seed.

'Paiute' orchardgrass — cooperative release with USFS and the Utah AES in 1983; drought and cold hardy to intermountain rangelands; excellent potential; selected from PI 109072 from Turkey.

'Ephraim' crested wheatgrass — cooperative release with USFS and the Utah AES in 1983; rhizomatous habit in sagebrush and pinyon-juniper habitats; good erosion control grass; selected from PI 109012 from Turkey.

'Salado' alkali sacaton — native grass collected in New Mexico and released by Los Lunas PMC for revegetating mine spoils and abandoned cropland; salt tolerant; selected for superior establishment; PI 434444.

'Duro' California buckwheat -- native shrub released by the Lockeford PMC in cooperation with the California AES for critical area plantings in California; can be direct seeded with grasses and legumes.

'Lassen' bitterbrush — 1984 cooperative release with USFS and eight other agencies; native shrub; excellent browse; adapted to Sierra Nevada, Cascades, and Idaho batholith.

'Hatch' winterfat — 1984 cooperative release with USFS and several SAES's; first release for species; should be standard component for many intermountain rangeland seed mixtures.

'Cedar' Palmer penstemon — 1984 cooperative release with USFS; excellent pioneer plant for mine spoils and other disturbed areas; also for arid range seed mixes.

'Summit' Louisiana sage — selected by Meeker PMC, released cooperatively with USFS; excellent pioneer ground cover, rhizomatous, and gives way to secondary species; adapted from Rocky Mountains to Sierra Nevadas.

'Scarlet' Mongolian cherry and 'Sakakawea' silver buffaloberry — in cooperation with the North Dakota, South Dakota, and Minnesota AES's. While these two varieties were released primarily for use for farmstead and field windbreaks, wildlife habitat, and natural area plantings in North Dakota, South Dakota, Montana, Wyoming, Nebraska, and Minnesota, the 'Sakakawea' silver buffaloberry is performing satisfactorily at the Aberdeen PMC.

Other upcoming releases of interest to range-oriented personnel.

T 17596 mountain rye — proposed cooperative release with USFS in 1986; perennial grass with excellent potential for cheatgrass ranges.

PI 421013 sulfur buckwheat — California PMS selection adapted to Sierra Nevadas; good low-growing ground cover with profuse yellow flowers.

Hobble Creek vasey big sagebrush — proposed cooperative release with USFS in 1986; very palatable winter browse for muledeer and sheep; should be excellent forage despite controversy over weediness of species.

T 21438 serviceberry — native selection by Meeker PMC scheduled for cooperative release with USFS in 1986; useful for mine reclamation.

Fountain Green bitterbrush — projected bitterbrush release for Utah, Colorado, and Wyoming, probably in 1986; will complement new 'Lassen' strain, which is adapted farther west.

PI 345600 siberian wildrye — pending release by Alaska PMC with excellent reclamation potential.

PI 432403 slender wheatgrass — selected for saline seep reclamation by Montana PMC.

PI 477962 engelmanndaisy — selected for high protein forage production in early spring by the Texas PMC at Knox City.

1983 Plant Variety Releases/SCS

Ephraim crested wheatgrass	ID
Rodan western wheatgrass	ND
Roundtree big bluestem	MO
Haskell sideoats grama	TX
Paiute orchardgrass	ID
Rumsey indiangrass	MO
Salado alkali sacaton	NM
Sabine Illinois bundleflower	TX
Rincon fourwing saltbush	CO
Golden golden chinquapin	KY
Autumn Amber aromatic sumac	NM
Bankers dwarf willow	KY

1984 Plant Variety Releases/SCS

Scarlet Mongolian cherry	ND
Sakakawea silver buffaloberry	ND
Duro California buckwheat	CA
San Luis slender wheatgrass	CO
Tropic Lalo paspalum	HI
Lancer perennial pea	MI/NY
Sea Isle Japanese sedge	NJ
Niner sideoats grama	NM
Immigrant forage kochia	ID
Hycrest crested wheatgrass	ID
Bozoisky-Select Russian wildrye	ID
Hatch winterfat	NM
Cedar Palmer penstemon	NM
Tropic Coral tall erythrina	HI
Lassen bitterbrush	CA
Summit Louisiana sage	CO
GSF-I eastern gama (germ plasm)	KS
GSF-II eastern gama (germ plasm)	KS

Conclusion

Uniform procedures for plant collection, evaluation, selection, and release enable evaluation data to be tabulated, entered, and retrieved from a data processing system. To date, the centers have released more than 250 varieties of native and introduced plants for specific conservation purposes; more than 150 of these are available from commercial sources. The tabulated benefit-cost ratio of the center's work is 9:1, on the basis of the retail value of the commercially available varieties; and there is potential for treatment of approximately 1.5 million acres per year using commercially available, cooperatively released varieties (1981 data).

Acquisition, Storage, and Distribution of Plant Germplasm

Louis N. Bass, *Agricultural Research Service, Fort Collins, CO*

Introduction

Plant germplasm in its broadest sense consists of all living species, subspecies, and their genetic variants. In recent years, interest in conservation of available plant germplasm for use in future plant breeding programs has increased steadily worldwide. Throughout the world, the major emphasis in germplasm conservation programs has centered around the most commonly used food, feed, fiber, and industrial crops of the country acquiring the germplasm. Probably the best organized and most comprehensive system in the world for germplasm acquisition, multiplication, evaluation, storage, and distribution is the one developed in the United States.

Acquisition

In the United States, germplasm acquisition is accomplished principally through plant explorations, plant exchanges, and voluntary contributions.

The United States has a long history of bringing in desirable plant germplasm from around the world, principally because most of our major crops originated elsewhere. Official recognition of plant introduction as a means of acquiring germplasm began in 1819 when the Secretary of the Treasury issued a request for American consuls to send useful plants back to the United States. The office of the Patent Commissioner conducted plant introduction from 1836 to 1862. During that period a government policy to collect and evaluate agricultural crops from around the world became firmly established. In 1862 the responsibility for plant introduction was transferred to the newly created Department of Agriculture and given increased emphasis.

The Department of Agriculture's emphasis became so great that in 1898 the Section of Seed and Plant Introduction was established. Since that time, approximately 500,000 plant introductions have been recorded and made available to scientists in the United States (Burgess 1971). However, many of the early introductions are not included in the present germplasm collections because during those early years no special provisions were made to preserve introduced germplasm. New accessions added to the introduced (PI) germplasm collection during the past 5 years have averaged over 11,400 annually.

Plant exploration is not a simple task. Much planning and preparation are required to put together and carry out a successful plant exploration. Planning a plant exploration involves first determining the scope of germplasm presently available for the subject species. Next, the geographic areas to be explored must be established. Once the proposed collecting areas have been determined, contacts must be made and working relationships set up with interested scientists in the host countries. The correct time to conduct the exploration must be determined before travel arrangements can be made. It is important that all the appropriate supplies and equipment be assembled before a collection trip begins. It usually requires a minimum of 2 years to prepare for a foreign plant-collecting trip. Domestic plant explorations are also carried out. These also require careful planning to be successful. The collected germplasm has to be cataloged, correctly identified, and in most cases multiplied before it can be distributed to plant scientists other than the collectors.

The U.S. National Plant Germplasm System acquires, through the Plant Introduction Office, considerable quantities of foreign plant germplasm through seed and plant exchances. Germplasm is also obtained through seed and plant exchanges. Germplasm is also obtained through scientist-to-scientist exchanges. Germplasm obtained through seed and plant exchange has to be multiplied before it can be made available through the appropriate working collection.

Worldwide, much emphasis is being placed upon the collection and preservation of germplasm, especially of the major crops. Source countries and the International Board for Plant Genetic Resources (IBPGR) are cooperating to determine areas within countries where additional genetic diversity may exist. Joint plant exploration trips are being planned and executed as rapidly as possible under existing financial resources. U.S. scientists are cooperating with the IBPGR and other countries in developing lists of available germplasm and planning and executing plant explorations. Joint plant explorations benefit both the host country and the other participating country because all germplasm collected is divided. Part of each sample collected remains with the host country to enhance its germplasm collection, and part returns with the participating collectors. In the United States, if the collector involved in a foreign plant exploration is other than the curator for the crops, part of the sample, after the PI number is assigned, goes to the crop curator and part goes to the scientists who carried out the exploration.

Seed propagated species turned over to the crop curators are multiplied as soon as possible. After multiplication, a portion of the seed is deposited in the National Seed Storage Laboratory (NSSL) (Bass 1981) for long-term storage and the remainder goes into the working collection for distribution to interested plant scientists.

Preservation

Germplasm preservation is accomplished in a variety of ways. Preservation in its native habitat is of considerable importance for many species, particularly tropical species. By protecting the native or natural habitat of a species, nature is allowed to preserve and perpetuate that species in the manner in which it has always been perpetuated. Preservation in the wild permits natural selection to occur. Under this method usually only those plants capable of adapting to natural variations in their environment survive.

Natural preservation can work well for perennial species and for species of which seeds cannot be dried and stored by conventional storage methods. Many perennial species, especially trees and shrubs, are preserved in botanic gardens, arboreta, and nurseries although they are not normally considered to be germplasm preservation centers. The United States is not greatly involved in setting aside natural areas for germplasm preservation. However, some native germplasm is preserved in protected forests and prairies.

The major part of the U.S. germplasm collection is preserved as seeds stored under controlled environmental conditions. However, centers for preservation of germplasm of vegetatively propagated species are being developed with several already in operation (Jones and Gillette 1982).

Publications which discuss broad aspects of germplasm availability, collection, and preservation as well as genetic vulnerability include: James 1967; Frankel and Bennet 1970; National Academy of Science 1972, 1978; Frankel and Hawkes 1975; IBPGR 1975; Matsuo 1974; Hawkes, et al. 1976, 1983; Williams 1976; Frankel and Soule 1981; Ng and Williams 1979; Witcombe and Erskine 1984; and Hanson, et al. 1984.

In the United States, germplasm preservation is the responsibility of the National Plant Germplasm System (Jones and Gillette 1982). In the past, the major emphasis for preservation was placed upon seed propagated major crops. In recent years there has developed an increased emphasis on preservation of vegetatively propagated crops.

The makeup of the National Plant Germplasm System was described in general terms by Jones and Gillette, 1982. The major components of the system are the NSSL, four Regional Plant Introduction Stations, the small grains collection, Potato Introduction Station, Plant Introduction Stations at Savanna, GA, and Miami, FL, and the clonal repositories.

The NSSL houses the base (reserve) collection of seed-propagated germplasm. The base collection is intended to meet the needs when no other source is available, not to serve plant breeders on a day-to-day basis.

Most seeds in the base collection are dried to approximately 5 to 6 percent moisture content and sealed in moistureproof, foil-laminated bags, then stored at -10 to -20°C. Those which cannot be frozen are stored at 5°C and 30 to 40 percent relative humidity. Seeds of most crops are expected to retain good viability for a minimum of 30 to 50 years under these conditions.

Seeds of germplasm accessions are tested for viability before storage and at 5-year intervals thereafter. When viability of an accession declines to a critical level it is multiplied and fresh seed placed in storage. All multiplication is done in the most suitable manner to preserve the genetic integrity of the accession.

Seeds in the working collections are dried to a safe level for storage at approximately 5°C and 35 to 40 percent relative humidity. Viability is monitored periodically. Multiplication is done whenever either viability or availability requires it. Each Regional Plant Introduction Station has a national responsibility to maintain a wide range of species each of which has its own requirements for satisfactory seed production and maintenance of genetic integrity.

Special curators are responsible for acquisition, maintenance, and distribution of certain large germplasm collections and for various genetic stock collections.

In recent years plans were developed to add to the National Plant Germplasm System a series of clonal repositories for vegetatively propagated crops, especially fruits, nuts, and berries. Several of those repositories are not in operation and others are under construction (Jones and Gillette 1982).

Internationally the IBPGR has worked to initiate, coordinate, and support, where necessary, a network of gene banks. That network has grown from 5 base collection centers in 1976 to 30 in 1983, located in 24 countries. The present aim is to develop about 50 base collections representing about 40 major crops by 1986 (Hanson et al. 1984). The IBPGR has issued a number of publications on the subject of germplasm preservation. Of special interest are the ones by Cromarty et al. 1982, and Dickie et al. 1984. Other useful articles on design and construction of seed storage facilities include Mumford 1965; and Justice and Bass 1978.

Storage Requirements

Seeds generally fall within one of two types for storage requirements, orthodox or recalcitrant.

Orthodox seeds can be dried to a relatively low (3 to 5 percent) moisture content without a reduction in viability percentage; recalcitrant seeds cannot. Because of the differences in their dessication characteristics, orthodox and recalcitrant seeds have different storage requirements.

Orthodox seeds retain their viability well when stored either under controlled low temperature and low relative humidity conditions or at a low seed moisture content (3 to 5 percent) in sealed, moisture-proof containers at a subfreezing temperature (Bass 1973, 1979, 1980a, 1980b, 1981). Within limits the lower the seed moisture content or relative humidity, the longer seeds will retain high viability even at ambient temperatures.

Recalcitrant seeds, however, cannot be dried to a low moisture content, at least by conventional methods, without loss of viability. Therefore, recalcitrant seeds cannot be stored safely at subfreezing temperatures. Such seed also cannot be stored in sealed containers at either warm or subfreezing temperatures. At present, recalcitrant seeds can be stored for a few days, weeks, or months at best under cool, humid conditions (King and Roberts 1979; Chin and Roberts 1980).

Research is under way at the National Seed Storage Laboratory and elsewhere to determine the potential value of cryogenic storage as a means of extending the storage life of both orthodox and recalcitrant seeds. Results to date (Stanwood 1980; Stanwood and Bass 1979, 1981; Stanwood and Roos 1979) show that most orthodox seeds can be stored in or over liquid nitrogen (-196°C) with no effect on viability. However, research has not been in progress long enough to show the long-term effects of cryogenic storage. Theoretically, storage at -196°C should extend seed storage life almost indefinitely. Storage of recalcitrant seeds at -196°C has not been accomplished for most kinds of seeds. Based on preliminary results, it appears that cryogenic storage may eventually play an important roll in the long-term preservation of both orthodox and recalcitrant seeds once suitable techniques are developed and refined.

The International Network of Germplasm Banks is intended to provide, on a continuing basis, the plant genetic diversity needed by plant breeders worldwide to improve the productivity of crops and minimize their vulnerability to insects, diseases, and environmental stresses. Small, well-documented subsamples from both working and base collections are available to plant breeders and research workers worldwide (Hanson et al. 1984). The only restrictions that might apply to some types of germplasm are quarantine regulations applied by the receiving country. Some types of germplasm have to be grown in isolation under quarantine before they can be released for general use. All germplasm accessions are replicated in two or more germplasm banks, preferably in different geographical locations.

Distribution

A base collection is a reserve or backup for a working collection. Theoretically, distribution from a base collection should be limited to supplying regeneration samples to the working collection when needed. However, in the case of the NSSL there are germplasm accessions of some crops in the base collection that are not in the working collections. Therefore, requests for seed of those accessions must be filled from the base collection. The quantity of seeds supplied from the base collection is limited and varies with the kind of seed. Breeders who receive seed from accessions either low in quantity or viability are asked to replenish the seed supply in the base collection.

The working collections are intended to provide starter samples of germplasm to plant breeders to meet their occasional needs for a broader genetic base than they can maintain in their active germplasm collection. Usually larger samples are distributed from a working collection than from a base collection. However, the working collection also has a limited seed supply and therefore a breeder can be supplied only enough seed for a start. If a large plant population is required, the breeder has to produce an increased seed supply from the limited quantity provided by the germplasm curator.

Each year the U.S. Plant Germplasm System provides seed of several thousand accessions to dozens of plant breeders, both domestic and foreign.

Summary

Acquisition, storage, and distribution of a broad base of genetically diverse plant germplasm is critical to future agricultural development worldwide.

To preserve the genetic variability of germplasm collections, great care must be taken to apply storage and regeneration procedures that will maintain the genetic integrity of each accession.

Cryogenic storage and tissue culture could be valuable preservation methods in the future provided suitable procedures can be developed for individual species.

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Seed Laws, Certification, and Testing for a Developing Native Seed Industry

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Abstract

The object of this paper is to review the areas of seed laws, seed certification, and seed testing for the purpose of identifying needs of a developing shrub and forb seed industry. The current status of labeling requirements for seeds other than agricultural or vegetable seeds is explained. Recently developed tree seed certification programs are described. And a progress report is made on developing seed testing rules for shrub and forb seeds.

Introduction

During the last decade more interest has developed in various land rehabilitation projects. Surely, some of this has resulted from western mining activity, but regardless of the stimuli, the end result has been good. Land managers are now keenly interested in restoring lands to their highest possible level of productivity for multiple use, including wildlife habitat and commercial grazing. As a result, an interest in various seed topics has resulted. For instance, collection of seeds is still rather laborious. This has led to the development of improved mechanical devices for the collection of some species. Many of these seeds offer tremendous problems for the cleanerman, leading to opportunities for the equipment engineer. Ecologists have demonstrated that some species are not adaptable to certain sites; this has led to an interest in developing a system for certifying seed origin. Also, there has been interest in nursery production of improved varieties. Persons associated with nurseries need to know more about dormancy factors and other seed biology traits to insure rapid uniform emergence. Seedsmen and purchasing agents alike need to understand seed quality so that they can merchandise seed effectively.

Because these and other topics relate in some way to seed laws, seed certification, and seed testing or quality determination, I will review these latter areas in hopes of stimulating your thoughts to the future needs of your developing seed industry.

Seed Laws

Seed laws exist primarily for consumer protection. However, they have also resulted in an orderly marketing of seed because the quality information required to be on a label is the basis on which seed is bought and sold.

The seed quality factors required to be on seed labels include an analysis of purity and germination. These will be discussed later when I talk about seed testing.

It is important to remember that seed laws were not imposed, but rather, they resulted because of a need to protect the consumer as well as the seller. Seed laws exist at two levels. Each State has its own seed law dealing with seed sold within that State. In addition, there exists a Federal Seed Act which has jurisdiction over seed moving from one State to another. The Federal Seed Act does not cover tree and shrub seeds, however, certain individual State laws do. The Seed Trade Buyers Guide (Seed World 1984), which summarizes State seed laws, indicates that 16 of the 50 States have seed laws that include tree and shrub species (table 1). However, most of these States do not require as extensive labeling for these species as are required for agricultural or vegetable seeds.

Table 1.—*States with seed laws covering tree and shrub seeds*

Arizona	Montana
Colorado	Nevada
Delaware	New York
Maine	North Dakota
Maryland	Pennsylvania
Massachusetts	Rhode Island
Michigan	Utah
Minnesota	Virginia

Because your industry is rather new and is in the process of developing, I think it is important to realize the variation that exists regarding labeling requirements between States and at the national level. You will have to decide what you would like to see regarding labeling and then try to have your thoughts prevail. One objection I've heard in the Pacific Northwest, where they are opposed to mandatory tree and shrub seed labeling, it that the length of time required for germination testing would interfere with current marketing practices. Often, seed is sold and the sale price is dependent on test results after the seed is shipped. Current "quick" viability tests could overcome this objection if the tests were recognized in State seed laws. Seed laws currently recognize germination tests and not other viability tests. Another reason why tree and shrub seeds are not included in a majority of the State seed laws is because these seeds are restricted in their marketing, with most sales being to government agencies or large private nurseries. Since the system seems to work the way it is, the feeling that "if it ain't broke, don't fix it" prevails.

Seed Certification

The rudiments of seed certification programs in the United States began in the early 1900's, but it was not until later that the more formal programs were instituted. For instance, certification did not receive legal status in Oregon until 1937 (Cowan 1972).

Seed certification programs were also developed in response to a need. The need was to insure continued supplies of new varieties and to maintain their genetic identity. Often, newly released varieties were simply given by the breeder to friends. Even though the intentions were good, the varieties often become contaminated and were not maintained for others to grow.

In my view, certification programs that apply to agricultural seeds are designed to insure a continued supply of new, improved varieties and to protect against their varietal contamination. To accommodate these goals, certification programs have developed a sophisticated system of records combined with various inspections, including inspections of fields, harvest and cleaning equipment, and the cleaned seed.

You may be asking, "how does this apply to the certification of tree and shrub seeds?" This is simply background information to help you identify differences between certification of agricultural seeds and native species.

In Oregon and Washington the conifer tree seed industry surfaced a genuine need to certify the origin of seeds. In the beginning, conifer cones were gathered indiscriminately from many areas and often bulked together. There was no verification of origin and often seeds were planted in areas outside their area of adaptation. As a result, a tree seed certification program evolved tailored to meet the industry needs. Tree seed zone maps were developed to aid in describing seed origin from seed collected from native stands. Zone boundaries in Oregon and Washington delineate drainage areas that are considered climatically different. Within the zones, elevation differences of 500-foot increments are also recognized.

Oregon tree seed zone map.

The Oregon and Washington programs began in 1966 after 10 years of discussions and proposals among seed users, producers, and foresters (Hopkins 1968). Today the programs are operating smoothly and have certified over 1 million pounds of seed representing 17,743 lots of 26 tree species. Those interested in a concise description of the Oregon and Washington program should refer to an Extension circular by DeYoe (1984).

Programs for certifying origin of shrub seeds are in effect in New Mexico and Colorado. Other States are now developing similar programs, but there is a lack of uniformity among these programs. It may be time for a concerted effort to study existing programs in order to standardize future ones to aid in transactions across State lines. Uniformity in shrub certification programs throughout the Western States could be beneficial to all participants in that confusion caused by nonuniformity could be avoided.

Certainly now is the time to evaluate the needs of your industry concerning certification. Like the tree seed program just described, origin is also important for shrub seeds. I understand that researchers are now working on the description of various plant ecotypes. Once completed, a map similar to the tree seed zone map previously described could be compiled and play a dominant role in a shrub and forb seed certification program. Such a map would aid people in obtaining seeds likely to fit their needs. Besides developing a program that would enhance revegetation by preventing losses due to planting species from noncompatible areas, I see several other benefits. The entire industry would become more unified and informed. Opportunities for more rapid advancement in seed processing, seed storage and seed testing would be a natural outgrowth of a unified approach to certification.

Seed Testing

Determination of seed quality is normally assigned to seed analysts. It is important that those measuring seed quality rely on standardized procedures, otherwise quality determinations could vary, depending on the procedures used. Fortunately, such standardized procedures exist in the United States through an organization called the Association of Official Seed Analysts (AOSA).

Seed analysts may work for State or Federal labs or they may work for commercial enterprises. Both use the same seed testing procedures, which are described in the *Rules for Testing Seeds* (AOSA 1981).

I see four areas relating seed testing to your industry: (1) a need to develop testing procedures oriented specifically to your species; (2) a special need to evaluate viability in addition to germination; (3) a need to evaluate other seed quality tests; and (4) a need to educate all users of these methods.

Even though rules exist which enable seed analysts to separate pure seed from a variety of inert material, I doubt that pure seed means the same to everyone in your industry. In the case of purity testing, it may be more of an educational problem than one of developing testing procedures. This is primarily because there has not been the close relationship between your industry and seed analysts as there has been with the agricultural seed industry and more recently with the tree seed industry. However, because some of the native species are often enclosed within bracts and a variety of floral parts, it is possible that alternative purity procedures could be developed. For instance separation of pure seed by air such as is done with seeds like bluegrass, bahiagrass, and blue grama might be possible, rather than by hand separation.

RULES FOR TESTING SEEDS

4.12, Table 5. Methods of testing for laboratory germination, TREE and SHRUB SEEDS

Kind of seed	Substrata	Temperature °C	Test duration days	Additional Directions
Abies amabilis Pacific silver fir	P	15-25	28	Light; prechill 0-5° C 14 days. Light; some sources may need prechill 21 days at 3-5° C.
Abies balsamea balsam fir	TB, P	20-30	21	Light; prechill 28 days at 3-5° C.
Abies concolor white fir	TB, P	20-30	28	Light; many lots complete in 14-21 days. A few sources from the Pacific coast region may need prechill for 3 weeks at 3-5° C.
Abies fraseri fraser fir	TB, P	20-30	21	Light; prechill 28 days at 3-5° C.
Abies grandis grand fir	TB, P	20-30	28	Light; prechill 14 days at 3-5° C. Vermiculite (P) is satisfactory. Dark; prechill 21 days at 3-5° C.
Abies homolepis nikko fir	TB, P	20-30	21	Light; prechill 21 days at 3-5° C.
Abies lasiocarpa subalpine fir	TB, P	20-30	28	Light.
Abies magnifica California red fir and shasta red fir	TB, P	20-30	21	Prechill 28 days at 3-5° C.

Germination methods for tree and shrub seeds. From AOSA Rules for testing seeds.

There is a big need to establish germination procedures for many of the seeds you deal with. AOSA rules are just now beginning to develop and test germination methods for shrub and forb species. This is where your industry could be of help by coordinating your research findings with AOSA in an attempt to develop germination tables similar to those for tree seeds. To accomplish this will require coordination through new or existing organizations. AOSA has a tree and shrub seed committee and would be glad to have good contacts with your organization for this purpose.

Because of the dormancy factor present in many of the native species, I believe that special consideration should be given to measuring viability by means other than the traditional germination test. It is possible to report a very low germination value and yet have a high viability due to ungerminated seeds that remain dormant through the germination test period. Seed analysts have tools, other than germination, available to test for total viability. The tetrazolium test is one such tool that has proven very useful for dormant species (Grabe 1970). Nurserymen may argue that total viability is of no value to them if they cannot predict when emergence will occur. However, until pretreatments to break dormancy can be devised for laboratory use, there seems to be a big need to utilize the T.Z. test. Once pretreatments are found that can be used by seed analysts and field personnel alike, the need for quick tests may decline. In the meantime, perhaps a multiple test combining actual germination performance with T.Z. or other quick viability results would be worthwhile. Such a test would allow the nurseryman or land manager to evaluate the degree of dormancy and he could adjust his pretreatments accordingly.

Traditionally, seed quality has been synonymous with purity and germination. However, seed laboratories today have a wide range of other tests that help their customers evaluate specific aspects of seed quality. Many of these tests could be very useful when applied to native species, particularly the T.Z. test and the X-ray test to detect empty and insect infested seeds.

Lastly, seed analysts could provide an educational service to your industry by holding workshops on seed quality tests. The purpose of this training would be to present an overall view as opposed to training expert analysts. Such as overview would be useful to seed collectors, seed cleanermen, seed dealers, contractors, nurserymen, and land managers alike, because they are the ones who need to understand and interpret test results.

Conclusion

I see yours as an exciting industry, one that is growing and one with endless opportunities for advancements and opportunities for success. If I have stimulated some thinking on your part about the future of your industry, I will have accomplished my purpose.

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Commercial Seed Production and Sales of Species for Revegetation

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I have chosen to review this subject from a historical perspective rather than trying to dwell on specific techniques of either production or sales. I will also confine my remarks to native species of grasses and forbs.

Production

I am sure that my entire allotted time could be used to explain the specific production techniques or sales program of a single species or cultivar. Further, the variables of climate, geography, soil type, growing season, equipment, and personal ingenuity vary so widely from one operation to another that it would be difficult, at best, to address these subjects in an objective manner.

Revegetation and the industries related to it had their origin during the Dust Bowl era in the Great Plains. Perhaps it is significant that we could say that 1985 is the 50th anniversary of our industry. At that time the pioneers of our industry collected and established plant materials without consideration for species or ecotype adaptability or desirability. Their challenge was to stop the devastation of the land by wind erosion.

The next period of activity of any consequence was the revegetation of areas created by the great disruptions of World War II. Again the plant materials were harvested from native stands wherever they could be found and planted with whatever equipment could be utilized for the purposes.

The greatest period of growth in the revegetation industry was during the Soil Bank Program in the 1950's. Early in this period we again relied on plant materials harvested from wild lands. The native species used were both cool and warm season species primarily adapted to the Great Plains. However, because of work done by the plant materials centers of the Soil Conservation Service, some agricultural experiment stations, and the Agricultural Research Service, we now began to see the development of specific cultivars of native species. The first materials available were varieties of sideoats grama and switchgrass.

Concurrent with the development of new cultivars, production techniques were being investigated. It was during the later years of the Soil Bank Program that we began to see production of native species using controlled multiplication techniques. Production was concentrated on irrigated lands, and some initial planting, establishment, and harvesting studies were conducted. Several new cultivars of a select group of species became available during the latter fifties and early sixties.

Some of the species for which varieties became available were big bluestem, sand bluestem, and indiangrass, in addition to sideoats grama and switchgrass mentioned before.

During the sixties and seventies two new markets developed for native species. The revegetation of areas disturbed by the construction of the interstate highway system was the first to impact the industry. During this period we saw some of the initial interest develop in the native forbs and flowers. Additional cultivars of both cool and warm season species were released for this use, and we saw an expansion of controlled production.

Most developments of production techniques came from the plant materials centers of the Soil Conservation Service with some innovation being developed by the producers themselves. We were still dependent on wild harvests of the grasses little bluestem, blue grama, western wheatgrass, bluebunch wheatgrass, etc., and we depended entirely on the collection of forb and flower seed from native stands.

The second development was the advent of concerns for the reclamation and revegetation of mined lands. Here again new cultivar development of more species came on stream. Many of these materials were developed for reclamation purpose exclusively rather than for revegetation and livestock utilization as before.

It would be an oversight to not note that materials were developed for wildlife use during this period. Most of these materials evolved from the same program and were developed for or adapted to this increasingly important need.

Today we see much of the seeds utilized in revegetation being grown under controlled, irrigated conditions in the Central and Western States. We have good information on stand establishment, irrigation scheduling, fertility needs, and harvesting techiques. Because of advances in crop production we now have good information on the use of herbicides and insecticides to complement the other production practices needed to improve and stabilize production.

The industry has developed techniques for the controlled production of some forbs and flowers, and we continue to make advances each and every day. However, we are still dependent on "wild land" harvests of several species of grasses and many of the shrub plants utilized in revegetation today. I suggest that we will continue to learn to domesticate these species, and reliable production techniques will be developed for most of the materials needed to address the revegetation problems we face today, as well as those that will confront us in the future.

Sales

As can be concluded from the production overview, most demand for seed of native species has been generated by an agency of Federal or State government or the mandates of a Federal program. We are beginning to see more and more consumer interest from the private sector especially in the Eastern areas of the United States. Because of heavy government involvement, seeds for revegetation are sold in a different manner than are most other crop seeds. To review sales from a historical perspective of some 50 years ago to today would seem in order.

Initially, most purchasing was a special order on contract basis directly with the government agencies. During the Soil Bank era, much of the seed was sold by harvesters to accumulators of seed who then conditioned these products and then sold them to soil conservation districts and other agencies or directly to people who seeded the product for the end user.

As controlled production became a factor, producers continued to use these same channels, or they acquired conditioning equipment and became involved in the sale of the product. Today, much of the seed sold continues to be sold to agencies and industry on a bid or contract basis. Some products for reclamation and agricultural use is sold based on long-term working relationships established over time. Much seed is sold through subcontractors who contract to do a complete seeding job and who have developed expertise in this particular phase of the industry. Most sales activities are conducted through contracts made at conferences and meetings such as this. Other activities which generate contracts involve direct mail and telephone contact with the organization or agencies involved in revegetation or seeding.

I do not see major changes in these approaches or techniques in the immediate future.

Some items of general philosophy must be integrated at this point concerning the seed industry itself, contract specification and requirements, and an overview of seed production as viewed in the present economic condition our agriculture faces today.

Three basic functions must be accomplished for the seed industry to fulfill its role: (1) The production function, which includes the expertise and resources needed to assure the supply of high quality product with known genetic makeup. (2) We must consider the conditioning, testing, storage, and transportation function with its requirements for particular equipment and expertise. This function is necessary to prepare the producer's product so it can be utilized by the end user. (3) There is the sales function. Those in sales would say that without the marketing function there is no need for any other activity. However, I am sure there are those who would dispute this fact. Each of these areas is a distinctly separate operation and a profit must be generated from each activity if the seed industry is to remain a viable one.

Secondly, I would like to review an area of concern to our industry. Recently, certain government bids have required a specific origin of named varieties of native seeds. We in the industry agree that if seed is harvested in the "wild" that origin should be of concern and specific requirements should be met. However, we know of no scientific basis for an origin requirement when a named variety is the item requested. I know of no plant variety that is aware of political boundaries established by man. If the variety is adapted, the area in which it is grown will have no effect on its performance.

Another area of concern is the use of common or native plant materials by government agencies when improved varieties are available. This usually happens when a price differential exists between a common or native type and the improved varieties. Most, if not all, varieties of native plants have been developed by public institutions, and we feel if the improved varieties are the best materials available they should be used unless prices are just totally out of line. Seldom has this been the case.

All producers and handlers of seeds for revegetation uses are also closely allied to the total agricultural industry, and this industry is having its problems at present. Seed production involves not only the normal inputs necessary for production but also, inherently by its very nature, an abnormal amount of risk. Weather, changing markets, and shelf-life are but a few of the considerations that must be given thought. The industry must maintain a structure that allows an adequate return on investment which not only covers cost but also allows consideration for the inherent risks associated with our industry.

In conclusion, I would like to state that the seed industry has come a long way in 50 years. I pledge that we, in the industry, will continue to build on our knowledge and expertise where production and sales of seed for revegetation are concerned. It will be through our working together with all disciplines needed to complete our job, and cooperation with agencies and end users, that we can face the challenges of the future. It is our shared responsibility to meet these challenges. To do so will conserve and protect the resources that we have been trusted to manage for the benefit of all the citizens of this great land.

Workgroup Reports

Information and Publications

Dick Hallman, *Chairman*

(Reported by Dan W. McKenzie, Forest Service, San Dimas, CA)

Activities

1. The VREW 38th annual report on the February 14 and 15, 1984, Rapid City, SD, meeting was prepared and 2,500 copies printed and distributed.

2. The agenda for the 39th annual meeting, February 10 and 11, 1985, Salt Lake City, UT, was prepared and distributed.

3. Two reports were completed and published by the Development Centers:

- Manual of Revegetation Techniques
- Range Water Pumping Systems—State-of-the-Art Review

4. Five articles generated by VREW were published in *Rangelands* magazine:

- "Arid Land Seeder Development," by Dan W. McKenzie, Carlton H. Herbel, and Ted Russell, December 1983.
- "Chains for Mechanical Brush Control," by Dan W. McKenzie, Frank N. Jensen, Thomas N. Johnsen, Jr., and James A. Young, June 1984.
- "Disk-Chain Implement Development for Seedbed Preparation on Rangeland," by Harold T. Wiedemann, Dan W. McKenzie, and Ted V. Russell, February 1985.
- "Low-cost Diagonal Fence Strainer," by Dan W. McKenzie and W.F. Currier, February 1985.
- "Foam Marking Systems for Rangeland Sprayers," by Maurice R. Gebhardt, L. Allen Torell, James A. Young, and Raymond A. Evans, February 1985.

5. Both *Fence Industry Magazine* and *Farm Show Magazine* ran an article on the diagonal fence strainer. Over 150 inquiries and requests for copies of the VREW report on rangeland fencing systems were received as a result of the article in *Farm Show Magazine*.

6. Two papers on VREW projects were presented at the 1984 winter meeting of the American Society of Agricultural Engineers at New Orleans, LA, December 1984:

- "Low-cost Diagonal Fence Strainer," by Dan McKenzie and W.F. Currier.
- "Improved and New Water Pumping Windmills," by Dan W. McKenzie.

7. In the proceedings of the Brush Management Symposium, sponsored by the Society for Range Management, a paper was included which made extensive use of VREW publications titled "History of Brush Control on Western U.S. Rangelands," authored by James A. Young, Raymond A. Evans, and Dan W. McKenzie.

8. Dan McKenzie presented a paper on range wind water pumping at one of the Water Pumping Sessions of the American Wind Energy Association annual meeting held in Pasadena, CA, September 24-26, 1984.

9. A paper on range rehabilitation equipment and the VREW was presented by Dan McKenzie at the Symposium on the Range Livestock Industry in the Great Basin, held during the winter 1984 SRM meeting at Salt Lake City.

Plans

1. Prepare, publish, and distribute VREW 39th annual report.

2. Prepare and distribute, 45 days in advance of meeting, the agenda for 40th annual meeting to be held in Orlando, FL, February 9 and 10, 1986.

Seeding and Planting

William J. McGinnies, *Chairman*

Seeding Rangelands with a Land Imprinter and Rangeland Drill in the Palouse Prairie and Sagebrush-Bunchgrass Zone

By M.R. Haferkamp, R.F. Miller, and F.A. Sneva,
Agricultural Research Service, Squaw Butte, OR

Drilling is considered the best method for planting seed except where terrain or obstructions limit its use. It is also the best method for obtaining uniform distribution of seed and proper depth of planting on a firm seedbed. For loose soils, cultipacking is often required to achieve the degree of soil firmness needed for optimum control of depth of planting and improving the water holding capacity of the soil surface, capillary transfer of water to seed, and seed to soil contact.

Broadcasting is generally used where drills cannot be used but there is some assurance seed will be covered. Uncovered seeds are exposed to rapidly fluctuating moisture conditions, temperature extremes, and depredation by birds and rodents.

The land imprinter developed by Robert M. Dixon, USDA-ARS, appears to be an effective implement for covering broadcast seed as well as producing microdepressions in the soil that improve water infiltration. Results have been good in the Southwestern United States, where much of the precipitation occurs as intense summer rains (Dixon 1981 and 1982; Frasier 1978). In the northern sagebrush-bunchgrass zone, where over one-half of the precipitation falls as snow and spring rain and most seedings are fall planted, the rangeland drill has traditionally been used. Data comparing the effectiveness of planting with the imprinter versus the rangeland drill in the Northwestern United States are lacking. To fill this void of information, studies were initiated in 1982 to compare the effectiveness of the land imprinter versus the rangeland drill for establishing Nordan crested wheatgrass (*Agropryon desertorum*) in the fall. Plantings were made on a variety of seedbeds in the Palouse Prairie and northern sagebrush-bunchgrass zone.

Study 1

Personnel from the Eastern Oregon Agricultural Research Center, in cooperation with the Soil Conservation Service, initiated a study in 1982 to evaluate the reestablishment of weeds and establishment of seeded plant species on ash-covered rangelands modified by fire, herbicides, or disking and planted by drilling or imprinting.

The study site located 43 km east of Ritzville, WA, is representative of areas receiving a 5 cm deposition of ash of the silt loam texture from the Mount St. Helens eruption. Soils are in the Benge series, silt loam in texture, and occur on 0-15 percent slopes. Elevation of 560 m and over 50 percent of the annual 31 cm of precipitation occurs from November to February.

Vegetation consists mainly of annual grasses, forbs, and bluegrasses with scattered plants of bluebunch wheatgrass (*Agropyron spicatum*) and Thurbers needlegrass (*Stipa thruberiana*). Dominant annual grasses include *Bromus tectorum* and *Ventenata dubia*.

Procedures

Seedbeds were either unprepared, disked in spring or fall, burned in summer or fall, or burned in summer and sprayed in fall with glyphosate (1.12 kg a.i./ha). Plots were seeded with Nordan crested wheatgrass at 6.7 kg pure live seed/ha. Seeds were planted with a rangeland drill or broadcast after the plots were imprinted with a land imprinter (2 m wide, 1 m diameter, 10 cm pattern depth) filled with water. Success of seedbed preparation and planting was evaluated by determining density of competing species in early May 1983 in ten 15- by 15-cm plots per treatment combination, and measuring frequency and density of crested wheatgrass seedlings in ten 30- by 60-cm plots per treatment combination in mid-June 1983 and 1984. Three replications were arranged in a split block design.

Results

Major effects of seedbed preparation compared to no preparation were as follows: removing litter by burning or disking; loosening seedbeds by disking; reducing total seedling density of competing species from 1304/m^2 to 928-1024/m^2, and density of annual forbs from 879/m^2 to 403-464/m^2 with fall burning or disking and summer burning plus fall spraying; reducing *Bromus tectorum* seedling density from 240/m^2 to 90 and 37/m^2 with summer burning alone and combined with spraying; and increasing density of *Ventenata dubia* seedlings from 166/m^2 to 527-611/m^2 with spring disking, summer burning or summer burning plus spray, and 271 to 296/m^2 with fall disking or burning.

More than five Nordan seedlings/m^2 were established in 1983 on all seedbeds where the dense litter layer had been removed, except the fall burned seedbeds planted with the imprinter (table 1). Seedling densities were greater than 40/m^2 from drilling on seedbeds where litter was removed by burning and *Bromus tectorum* seedling density was reduced to less than 40/m^2 with glyphosate. Drilling significantly (P<0.01) increased seedling density on seedbeds prepared by fall burning and summer burning plus spray. Distribution of seedlings was more even from drilling (90 to 100 percent) than from imprinting (40 to 73 percent) on these same seedbeds.

Seedling densities declined 36 to 100 percent in 1984 with densities remaining greater than 5/m^2 only on the burned or burned plus spray seedbeds planted by drilling, and the burned plus spray seedbeds planted by imprinting. Although densities of over 5/m^2 were established in 1984, the fate of the plants is questionable since they are growing in dense stands of *Ventenata dubia.*

Table 1.—*Mean density of crested wheatgrass seedlings and plants growing on range seeding plots near Ritzville, WA, in June 1983 and 1984. Data from three replications arranged in a split block design.*

Method of planting	Unprepared	Disk		Burn		Summer burn
		Spring	Fall	Summer	Fall	Fall glyphosate
			1983 number/m^2			
Drill	1.1a[1]	7.0a	7.4a	19.2a	21.7a	41.1a
Imprint	0.4a	5.4a	11.7a	17.0a	3.2b	22.8b
			1984 number/m^2			
Drill	0.7a	1.4a	0.2a	5.9a	5.0a	16.1a
Imprint	0.0a	0.5a	1.6a	3.2a	1.1b	9.5b

[1]Means within columns per year followed by the same letter are not significantly different at P<0.01.

Study 2

Beginning in the fall of 1982, Nordan crested wheatgrass seed was planted on an *Artemisia tridentata* subsp. *wyomingensis/Stipa thurberiana* habitat type located on the Squaw Butte Experiment Station, Burns, OR. At this location the sandy loam soil (Xerollic durorthid) is approximately 47 cm deep; elevation is 1,372 m; shrub canopy cover is 15.3 percent; grass basal cover is 21.3 percent; and herbage production averages 627 kg/ha. Annual precipitation averages 29 cm with peak periods from October to January and May to June.

Procedure

Seedbeds were either left unprepared or prepared by brush beating, or brush beater plus disking. Brush beating was applied during August 1982, and seedbeds were disked in August 1982 and again in October 1982 after *Bromus tectorum* seedlings had emerged. Nordan seed was planted at the rate of 6.7 kg pure live seed/ha by broadcasting before or after imprinting and with a rangeland drill equipped with regular or deep furrow openers in October. Seedling densities and frequencies were determined in ten 30- by 60-cm plots per treatment combination in September 1983 and August 1984. Four replications were arranged in a split block design.

Results

Firm seedbeds remained without preparation or after brush beating that left herbaceous plants rooted. Brush beating plus disking removed brush and resident herbaceous plants and provided a loose seedbed. An average of 8 and 12 seedlings/m^2 were established by drilling on the firm seedbeds with perennial competition present, in contrast to an average 2.5 seedlings/m^2 established by imprinting (table 2). The most seedlings, 24 and 38/m^2 were established by drilling and broadcasting seed before imprinting, respectively, on the loose seedbeds prepared by brush beating plus disking. Deep furrow drilling and broadcasting seed after imprinting established fewer seedlings on the loose seedbed. The poor establishment may have resulted from deep seed coverage with drilling and inadequate coverage after imprinting. The best seedling distribution, as determined by frequency, occurred with drilling after brush beating (72 percent) and brush beating plus disking (95 percent) and imprinting (80 to 98 percent) following brush beating plus disking.

Seedling densities in 1984 increased on all except the unprepared seedbeds planted with deep furrow drill, and brush beat plus disked seedbeds planted by broadcasting and imprinting. Regardless of seedbed preparation regular drilling established over 13 seedlings/m^2 while imprinting established over 13/m^2 only on the brush beat plust disked seedbeds.

Table 2.—*Mean density of crested wheatgrass seedlings and plants growing on range seeding plots on the Squaw Butte Experiment Station in southeastern Oregon in September 1983 and August 1984. Data from four replications arranged in a split block design.*

Seedbed preparation	Regular drill	Deep furrow drill	Imprint seed	Seed imprint
		1983 number/m^2		
Unprepared	9a[1]	7a	2a	3a
Brush beat	14a	10ab	2b	3b
Brush beat + disk	24b	3c	10c	38a
		1984 number/m^2		
Unprepared	13a	5a	7a	6a
Brush beat	18a	12ab	8b	9b
Brush beat + disk	29a	6c	14bc	21ab

[1]Means within rows followed by the same letter are not significantly different at P<0.01.

Summary
September through June precipitation in 1982 to 1983 and 1983 to 1984 was 38 and 33 percent above average in Washington and 10 and 24 percent above average in Oregon. In these moist conditions of 1982 to 1983, 10 seedlings/m^2 established on 37 percent of the plots and 5 to 10 seedlings/m^2 established on 29 percent. Plant densities remained greater than 5/m^2 on 65 percent of the plots in 1984.

Removal of the dense litter cover and plant competition enhanced seedling establishment at both sites. Burning and disking removed litter and exposed mineral soil, and disking provided a loose seedbed allowing maximum penetration of the land imprinter.

Under the conditions studied, imprinting was superior to drilling only once during 1983 on the brush beat plus disked seedbeds in Oregon, and this difference disappeared in 1984. Drilling was superior to imprinting on firm seedbeds prepared by fall burning, summer burning plus fall glyphosate and brush beating in both 1983 and 1984. Drilling and imprinting produced similar results on unprepared seedbeds and those prepared by disking, summer burning and brush beating plus disking. The cause for similar seedling densities from drilling and imprinting after summer burning when compared to the superiority of drilling over imprinting after fall burning is not clear. Summer burning, however, produced twice as many *Ventenata dubia* plants, but only one-half as many *Bromus tectorum* plants as compared to fall burning.

Imprinting for fall seedings did not improve seeding success in these studies. However, the practice produced stands comparable to drilling on loose seedbeds. The method may be a viable alternative to drilling on loose seedbeds produced by disking and other disturbances or where drill rows are viewed as esthetically unappealing. Economic differences between seeding by the two techniques were not fully evaluated, but the water-filled land imprinter probably requires more horsepower than a comparable sized rangeland drill.

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Interseeding with a Modified Sieco Fireplow Can Result in Increased Seedling Numbers[1]

By Richard Stevens, Utah Division of Wildlife Resources, Ephraim, UT

Herbage production and quality of forage in monograss stands can be improved by interseeding forbs, shrubs, and additional grass species. The Sieco fireplow (fig. 1) has been used in conjunction with the Hansen seeder or thimble seeder in scalping and interseeding desirable species (McKenzie and others 1981; Stevens 1979). The seeding device is connected to the fireplow, and a small chain is generally dragged behind the seeder in an effort to cover the seed. Three basic scalpers are used in interseeding: (1) those that employ disks; (2) those that use a plow, generally a sulky type, single or double (V-shaped); and (3) those that employ plows and disks in combination, such as the Sieco fireplow.

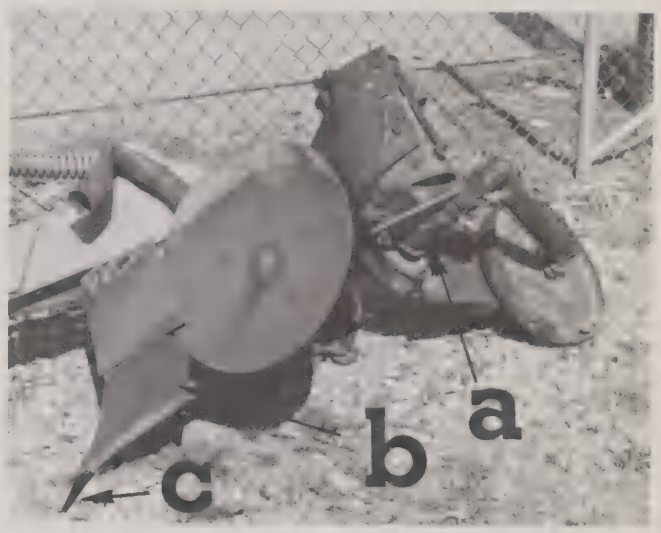

Figure 1.—(a) Hansen seeder attached to Sieco fireplow. (b) Sieco fireplow with V-shaped, heavy-duty, sulky-type plow and two 16-inch disks. (c) Point of attachment of 3/4-inch steel spike that protrudes 6 inches below base of V-shaped plow.

The scalps made with either a disk, plow, or combination of both result in scalps with compacted, smooth bottoms (fig. 2). Soil compaction and smoothness of the scalp vary with soil type and mositure content. Smooth, compacted scalp bottoms are not ideal seedbeds and may be a cause of lower than expected seedling numbers. The heavy-duty V-shaped sulky-type plow on the front of the Sieco fireplow is flat bottomed. Down pressure and weight of the plow compacts the soil and leaves a fairly flat surface. Seeds are deposited on the compacted, flat surface behind the plow point. To improve seeding success, the seeded area needs to be loosened and roughed up so seed can be covered for better germination and establishment.

[1]Funds were provided by Federal Aid to Wildlife Restoration Project W-82-R and USDA Forest Service Intermountain Research Station, Ogden, UT.

We attached a ¾-inch steel spike to the V-shaped plow point, which extended 6 inches below the point and at the same angle as the point of the plow. We felt that this extended point could loosen the soil and create more microhabitat opportunities for seed placement (fig. 3). With the soil loose, the chain drag would be able to do a better job covering the seed.

An evaluation seeding was done to determine what, if any, difference in seeding success occurs in scalps made with a Sieco fireplow and those made with a modified Sieco fireplow. We theorized that a loosened seedbed as opposed to a compacted one could provide a more ideal microhabitat for germination, root penetration, and eventual establishment.

Figure 2.—Interseeder scalp made with Sieco fireplow. Note compacted, smooth bottom of scalp.

Figure 3.—Interseeder scalp made with Sieco fireplow that has 3/4-inch steel spike attached and protruding 6 inches below base of plow point.

Study Site and Methods

Scalping and seeding trials were conducted in a crested wheatgrass stand on a clay loam soil at Ephraim, Sanpete County, UT. Eight species (table 1) were seeded into Sieco fireplow scalps with and without the spike attachment through a Hansen seeder attached to the plow (fig. 1). A looped drag-chain followed behind the seeder.

On April 4, 1984, each species was seeded at random into two 200-foot scalp rows made with a standard Sieco fireplow and two 200-foot scalped rows made with a Sieco fireplow-spike combination. On July 10, 1984, three plots 15 feet long were located and marked at random in each scalp row. Total number of seedlings in each plot were counted and averaged per linear foot.

Results

There were considerably more seedlings in the scalps for most species where the seedbed was loose and seeds were covered more completely (plow-spike attachment) (table 1). Alfalfa, crested wheatgrass, small burnet, and fourwing saltbush are species that generally come better when seeds are covered. These species produced the greatest increase in number of seedlings with the modified Sieco fireplow. Rabbitbrush, sweetclover, forage kochia, and big sagebrush are considered surface-seeded or shallow-seeded species. Difference in number of seedlings between treatments was not as great for these four species.

We concluded that a spike attached to the point of a Sieco fireplow can help create a more desirable seedbed and enhance seedling establishment for some species.

Table 1.—*Mean number of seedlings per linear foot of interseeding scalps made with a Sieco fireplow and a Sieco fireplow with a 6-inch-long spike attachment. Seeded, April 6, 1984. Seedling count, July 10, 1984.*

Species	Sieco fireplow	Sieco fireplow with spike	Relative % increase
Alfalfa ladak (*Medicago sativa*)	5.1	133.7	96
Fairway crested wheatgrass (*Agropyron cristatum*)	1.8	4.5	60
Small burnet (*Sanguisorba minor*)	2.0	3.4	41
Fourwing saltbush (*Atriplex canescens*)	0.9	1.4	36
White rubber rabbitbrush (*Chrysothamnus nauseosus* ssp. *albiculis*)	1.1	1.4	21
Yellow sweetclover (*Melilotus officinalis*)	19.9	22.8	13
Forage Kochia (*Kochia prostrata*)	2.7	3.0	10
Wyoming big sagebrush (*Artemesia tridentata* ssp. *wyomingensis*)	1.3	1.3	0

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Depth of Interseeding Scalps Can Affect Growth of Seeded Mountain Big Sagebrush[1]

By Richard Stevens, Utah Division of Wildlife Resources, Ephraim, UT

Throughout the Western United States, hundreds of thousands of acres of rangeland have been seeded to, and are dominated by, desert wheatgrass (*Agropyron desertorum*), crested wheatgrass (*A. cristatum*), and other introduced and native grass species. Monostands, seeded or natural, of any one species do not constitute good, healthy wildlife or livestock ranges. One means of establishing desirable species into grass stands is interseeding, which includes removing competitive vegetation from selected areas or spots and seeding in desirable species. Removal or reduction of vegetation allows for establishment of seeded species.

Interseeding on Western ranges resulted generally in increased forage production and diversity, improved water retention on the sites, and increased infiltration (Branson and others 1966; Fisser and others 1974; Griffith and others 1985; Neff and Wight 1977; Rauzi 1974; Stevens and others 1981; Wight and Siddoway 1972; Wight and White 1974).

McKenzie and others (1981) and Stevens (1979) reported on the development of interseeding equipment and the 1977 establishment of interseeding studies. Their studies included three types of scalpers and seeding of various species. The most successful seeding occurred in scalps made with a Sieco fireplow (fig. 1), a V-shaped heavy-duty, sulky-type plow with two 16-inch disks, one on each side which makes a scalp 30 inches wide and up to 9 inches deep.

Within any given Sieco fireplow row, scalp depth varied from the soil surface (0 depth) to 9 inches deep. Five species established well within the rows (fig. 2). The size (height and crown) differences in the seeded mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) plants became evident 5 years into the study. Upon closer inspection, it appeared that the larger shrubs occurred where the scalps were most shallow.

More moisture should be made available for plant use in the scalps and particularly at the lower point in each scalp row (deepest part of scalp). If moisture is a limiting factor, then shrubs in the deeper part of the scalp should do better than those located at shallower depths. Generally the two most limiting soil nutrients for sagebrush on Western ranges are nitrogen and phosphorus. Nitrogen and phosphorus in semi-arid soils tend to be highest at and just below the soil surface. If the surface soil is removed by scalping, then seedlings established in scalps below the soil surface may not grow as well as those nearer or on the surface.

Figure 1.—Sieco fireplow.

Figure 2.—Mountain big sagebrush, forage kochia, Ladak alfalfa, showy goldeneye, and small burnet.

During the seventh growing season (1984) of the study reported by Stevens (1979), 20 rows were picked at random. Within each row a point was selected at random that was the beginning point for measuring the maximum height and crown of the first 25 mountain big sagebrush plants encountered. The depth of the scalp at the base of each shrub was recorded. Mountain big sagebrush plants had established on the berm of some scalps. Maximum height and crown of all such shrubs associated with the 20 sample rows were measured.

[1]Funds were provided by Federal Aid to Wildlife Restoration, Project W-82-R and USDA Forest Service Intermountain Research Station, Ogden, UT.

Four soil pits were dug between rows, in undisturbed soil. Soil samples were taken at 2-inch intervals down to 13 inches. Soil samples were analyzed for percent nitrogen, percent phosphorous, and pH. No hardpan was encountered.

Height and crown of mountain big sagebrush plants did vary with scalp depth within each row (fig. 3). The smallest shrubs (average 4.6 inches in height with 2.7-inch crown) occurred in the deepest (9 inches) and most abundant part of each row. The largest plants (average 10 inches in height and 10.1-inch crown) occurred where the scalps were only 1 to 2 inches deep. Shrub size decreased as scalp depth increased. The largest seeded sagebrush plants (average 27.4 inches in height with a 14-inch crown), were those that established on top of the scalp berms (fig. 3).

Soil pH (range 7.6 to 8.0) and percent phosphorous (range 0.12 to 0.09 ppm) did not vary much with soil depth. Total nitrogen (fig. 3) was highest (0.18 percent) between the surface and 1-inch depths and diminished with deeper soil depth. The smallest shrubs occurred in the areas where available moisture was highest, indicating that moisture was not a limiting factor in the growth of mountain big sagebrush. It appeared that nitrogen may be a limiting factor to growth. Mountain big sagebrush plants that established on the scalp berms (fig. 3) where surface soil was layered over surface soil (double surface depth and double the amount of nitrogen) were on the average over 2.5 times larger than the largest shrubs growing within the scalps.

Two years following scalping and seeding, all vegetation (intermediate and crested wheatgrass) on an area next to the scalp was killed with the herbicide glyphosate (Roundup), broadcast seeded, and lightly harrowed. Soil nutrients were disturbed very little by the treatment. Four years after seeding, mountain big sagebrush plants that established in the spray plots (fig. 4) were as large as the largest shrubs in the scalped rows (fig. 3), even though they were 2 years younger.

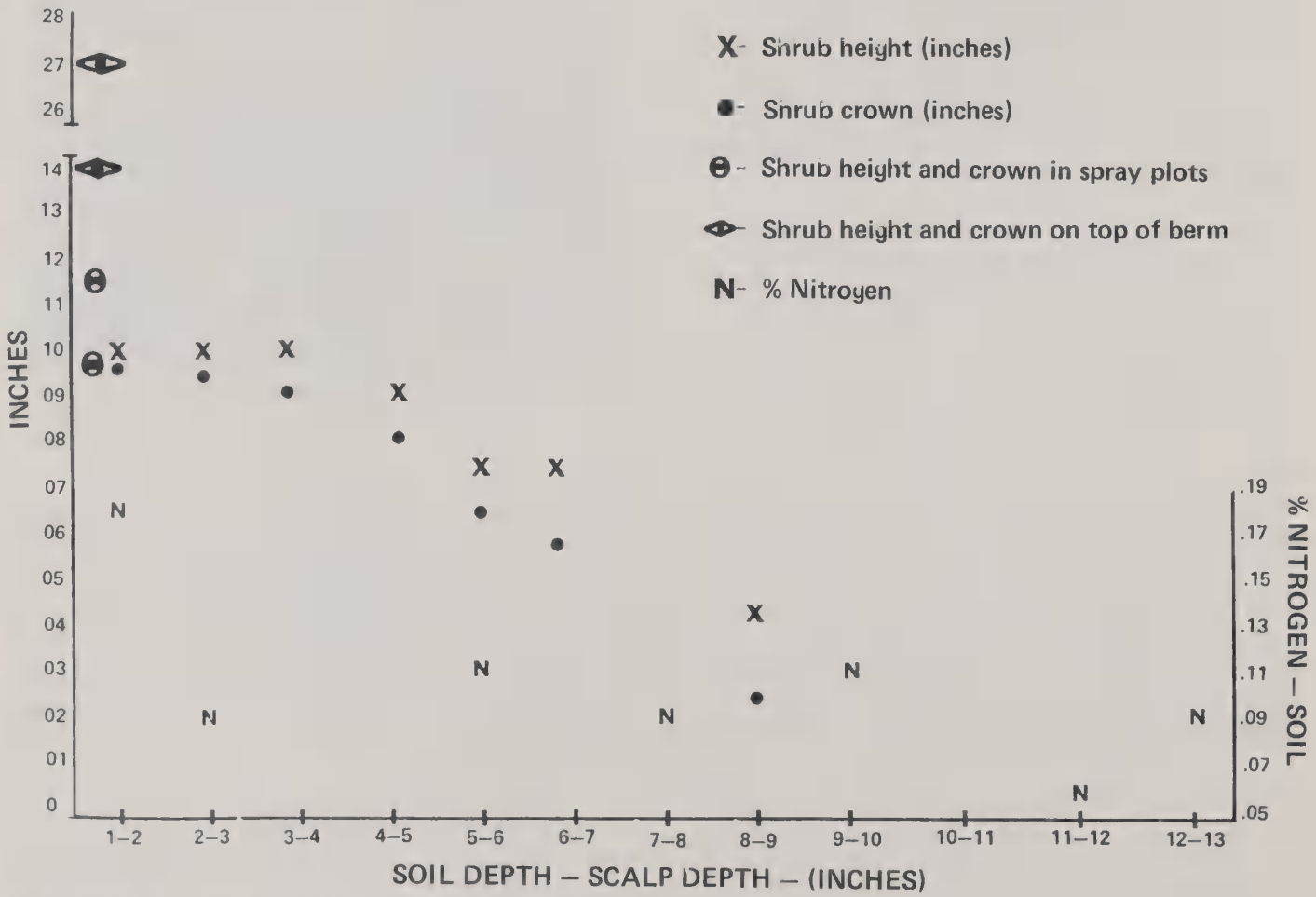

Figure 3.—Mean height and crown of mountain big sagebrush plants growing in scalps of various depths on scalp berms and on spray plots with corresponding soil nitrogen content.

Figure 4.—Intermediate crested wheatgrass stand sprayed with glyphosate (Roundup) and seeded to mixture of shrubs and forbs. Four years following seeding, mountain big sagebrush and white rubber rabbitbrush are principal visible shrubs.

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Arid Land Seeding

Harold T. Wiedemann, *Chairman*

The workgroup concentrated its effort on innovative new equipment development projects and potential funding. Reports were made on the disk-chain (Texas Agricultural Experiment Station), punch planter (University of Idaho), and the RIM (Range Improvement Machine) seeder, (USDA-ARS and Montana State University) at the summer VREW meetintg of the exploratory committee. Another article was published in *Rangelands* (Feb. 1985) on a promising equipment development project. This article was on the disk-chain for seedbed preparation, while the first article was on the arid land seeder. Additional reports are included under individual headings.

Flexing Roller For Disk-Chains

By Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, TX

The research disk-chain developed by the Texas Agricultural Experiment Station for the preparation of seedbeds on rangeland used 2-inch anchor chain, 24-inch disk blades, and was 24 feet wide. Research to determine the influence of operating mass on draft and soil penetration necessitated the use of 2.5- and 3-inch chains. These larger chain sizes resulted in widths of up to 41 feet using the same number of disk-blades (20) as the original research unit. A flexing roller that would telescope to different widths was designed using a 20-inch-diameter roller to overcome the breakage problem of the original 12-inch (pipe) roller. A ridged pipe brace with clevis connections was necessary between the flexing joint and the triangular tow plate for proper operation. The flexing joint was constructed from 1-inch plate and D-6 track carrier rollers. Preliminary pulling results indicate that the draft of the larger disk-chains will average between 250 and 500 pounds per blade. The new roller will allow extensive evaluation of different size disk-chains. This project has been funded in part by VREW.

Close-up of flexing roller with ridged pipe brace.

Disk-chain with flexing roller developed to prepare seedbeds on rangeland.

Equipment for Seeding Fourwing Saltbush

By Darrell N. Ueckert, Joseph L. Petersen, David Whipple, Texas Agricultural Experiment Station, San Angelo, TX; Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, TX

Data from preliminary trials on oilwell reserve pit soils in 1982 suggested that stand densities and standing crops of fourwing saltbush were significantly greater where seeds were broadcast onto contour furrowed soils compared to soils which were disked only. Research was initiated in 1984 to develop and evaluate equipment for drill-seeding fourwing saltbush in furrow bottoms.

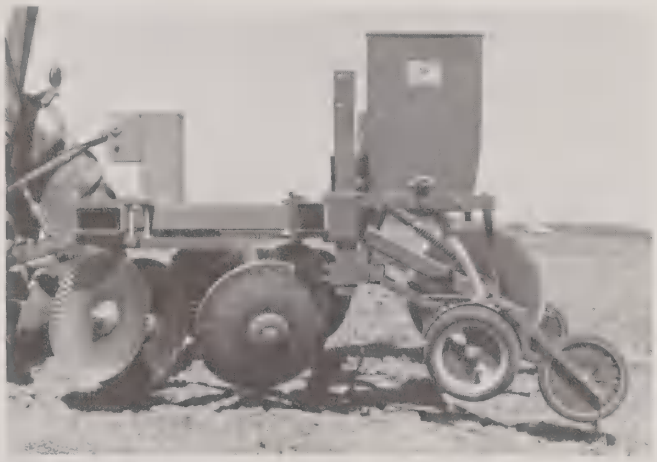
The prototype consisted of: (1) two sets of rolling disk bedders arranged on a three-point-hitch-mounted implement carrier to construct furrows on 64.5-inch centers (rolling disk bedders were selected to permit use on rocky or brush-infested sites); (2) two seedboxes with internal, adjustable width seed-metering rings (chain driven by a coulter disk); and (3) two double-disk openers with depth bands and packerwheels aligned to plant in the furrow bottoms. All components were shelf items manufactured by The Tye Co. (P.O. Box 218, Lockney, TX 79241).

Experiments were established in spring and autumn 1984 at several locations, using various sources of fourwing saltbush seed, to compare seedling establishment achieved with the prototype seeder compared to that achieved by drill seeding with the same unit on a firm, flat seedbed. The disk bedders were removed for the latter treatment and in some experiments freshly disked seedbeds were firmed with a cultipacker or roller packer prior to drilling.

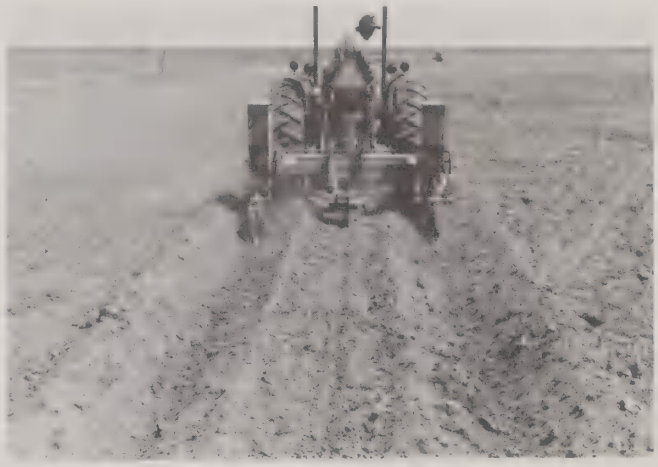
The seed-metering mechanisms were easily calibrated and delivered a constant flow of seeds in the range of 1 to 5 pounds bulk seed per acre. Plugged seed tubes were a problem with excessively trashy seed lots. The rolling disk bedders performed well on rocky and brush-infested sites.

No effective precipitation was received in spring 1984 but above-normal precipitation occurred in autumn 1984. Fourwing saltbush seedling emergence was significantly greater on firm, flat seedbeds drill-seeded at a ½-inch depth compared to that on adjacent plots drill-seeded at the same depth in furrow bottoms. Mean seedling densities were 2 to 10 times greater on firm, flat seedbeds (range 23 to 48 plants per 10 m row segment) compared to those in furrow bottoms (range 5 to 20 plants per 10 m row segment). Reduced seedling emergence in furrow bottoms was attributed to excessive soil movement into furrow bottoms by heavy rainfall.

Future work will include evaluation of furrow dikers with broadcast seeding to achieve seeding into a variety of microrelief possibilities.



Prototype fourwing saltbush seeder developed by the Texas Agricultural Experiment Station for drill seeding in furrow bottoms. Components were shelf items manufactured by The Tye Co., Lockney, Texas.



Furrows made with rolling disk bedders are on 64.5-inch centers. Double-disk openers plant fourwing saltbush seeds 1/2-inch deep in furrow bottoms.

Plant Materials

Wendall R. Oaks, *Chairman*

The Plant Materials Workgroup objectives include:

1. Identification and recommendation of needed research on species, techniques, and equipment for reseeding, harvesting, and processing plant materials.

2. Dissemination of new information on adapted species, production and establishment techniques, and processing plant materials.

3. Stimulation of interaction between and among private, local, State, and Federal groups concerned with development, production, and use of new plant materials and techniques for their application.

Examples of projects and/or activities include:

1. Developing a listing of cultivars for reclamation.

2. Developing a slide set and narrative of new cultivars for range, pasture, and critical area stabilization, etc.

3. Maintaining a national source list of plant materials and cultivars for use in critical area stabilization, rangeland, etc.

Sources of Seed and Planting Stock pamphlet remains current and will not be revised until spring 1986. Copies remain available from: USDA Forest Service, Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, MT 59801.

In keeping with the workgroup's objective of disseminating information on plant materials, the following table lists the newly released plant materials. Only materials having application to conservation have been included.

Plant Materials Releases

Scientific name	Cultivar	Common name	PI or other No.	Source	Date released	Agency Participation		PMC
						Primary	*Others*	
(GRASSES) Agropyron cristatum X desertorum	Hycrest	Crested wheatgrass	--	USSR	1984	ARS	SCS, UT AES	Meeker, CO
Agropyron trachycaulum	San Luis	Slender wheatgrass	483079	CO	1984	SCS	AES-CO, UT, NM, ARS	Meeker, CO
Bouteloua curtipendula	Niner	Sideoats	478839	NM	1984	SCS	AES-CO, NM	Los Lunas, NM
Paspalum hieronymii	Tropic Lalo	Pospalum	310108	Brazil	1984	SCS	AES-HI	Hoolehua, HI
Psathyrustachys juncea	Boziosky-select	Russian wildrye	--	USSR	1984	ARS	SCS, AES-UT	Bridger, MT
Tripsacum dactyloides*	GSF-I	Eastern gamagrass	483447	KS	1984	SCS	AES-KS, OK	Manhattan, KS
Tripsacum dactyloides*	GSF-II	Eastern gamagrass	483448	KS	1984	SCS	AES-KS, OK	Manhattan, KS
(LEGUMES & FORBS) Carex kobomugi	Sea Isle	Japanese sedge	66515	Sweden	1984	SCS	AES-NJ	Cape May, NJ
Heliopsis helianthoides	Midas	Rough oxeye	421379	KS	1984	SCS	AES-KS, NE, Dept. of Roads-NE, KS	Manhattan, KS
Kochia prostrata	Immigrant	Forage kochia	314929	USSR	1984	USFS	SCS, AES-UT, ID, OR, NV	Aberdeen, ID
Lathyrus latifolius	Lancer	Perennial pea	477009	MI	1984	SCS	MI DOT, MI DNR	Rose Lake, MI
Penstemon palmeri	Cedar	Palmer penstemon	T3885	UT	1985	SCS	USFS, AES-NM, CO, UT, UT DNR	Los Lunas, NM
(WOODY PLANTS) Artemesia ludoviciana	Summit	Louisiana sage	T21474	ID	1985	SCS	USFS, AES-CO, UT, ID	Meeker, CO
Eriogonum fasciculatum	Duro	California buckwheat	19947T	CA	1983	SCS	ARS-CA	Lockeford, CA
Eurotia lanata	Hatch	Winterfat	T7844	UT	1985	SCS	USFS, AES-NM, CO, UT, ID	Los Lunas, NM
Prunos fruticosa	Scarlet	Mongolian cherry	478003	China	1984	SCS	AES-ND, SD, MN	Bismarck, ND
Purshia tridentata	Lassen	Bitterbrush	--	CO	1984	USFS	SCS, UT DWR, AES-CA, ID, OR, NV	Lockeford, CA
Rhus trilobata	Autumn Amber	Skunkbush sumac	T9467	TX	1984	AES-NM	SCS	Los Lunas, NM
Shepherdia argentea	Sakakawea	Silver buffaloberry	478005	Canada	1984	SCS	AES-ND, SD, MN	Bismark, ND

*Germplasm release

Plant Materials Workgroup representatives gave three special reports at the VREW meeting:

1. "Selection of Plant Materials for Texas Roadsides," Wayne G. McCully, Texas Transportation Institute.

2. "Plants for Western Colorado, Eastern Utah, and Southwest Wyoming," Sam Stranathan, Soil Conservation Service.

3. "Recent Plant Releases for Western Wild Lands," Richard Stevens, Utah Division of Wildlife Resources, and Stephen B. Monsen, Forest Service.

Selection of Plant Materials for Texas Roadsides

By Wayne G. McCully, Texas Transportation Institute, Vernon, TX

The philosophy of managing roadside vegetation has changed in recent years from an agronomic approach to one stressing ecology and range science principles. The Texas Highway System, incorporating slightly more than 1 millions acres of right-of-way, has implemented a systems approach to roadside maintenance administered by the Landscape Section. This systems approach integrates:

- Basic objectives of maintenance activities (safety, protection of investment, user comfort, esthetics).
- Sound agricultural principles (range management concepts, erosion control, wildflower preservation and propagation, adapted planting materials, planting installation).
- Applicable maintenance methods (mechanical and chemical mowing, use of herbicides, removal of sediment from drainage channels).
- Department policies ("Good Neighbor" policy, control of noxious weeds such as wildoats, bindweed, and African rue).

Utilizing the ecological concept in managing roadside vegetation places greater dependency on the use of native plants along a highly visible highway corridor. Native plant materials are installed along the roadside to:

- Accelerate secondary succession in conjunction with construction, reconstruction, or maintenance.
- Control erosion, dust and sedimentation.
- Complement activities on adjoining properties.
- Create a visual experience for the pleasure of the driving public.
- Promote safety by lessening driver fatigue and increasing driver awareness.

Both warm- and cool-season plants are utilized on the Texas Highway System. Permanent erosion control and ecological stability are achieved by installing perennial warm-season grasses. The spring wildflower show is provided by a good variety of mostly annual cool-season forbs. This program has been in force since the early 1930's. Perennial warm-season forbs furnish summer and fall colors. These have become more prominent with restricted roadside mowing.

Native perennial grasses are the primary plant materials for use in erosion control. A comprehensive set of specifications exists, but there still is a place for fine-tuning to fit special situations and exposures. There has been an increased dependency on the use of natives such as the various bluestems, panicums, and paspalums. Introduced species such as buffelgrass, yellow bluestem, johnsongrass, and bermudagrass have some desirable attributes for highway use, but they often become weedy. A background of varietal and biotype development for natives by State experiment stations and the Soil Conservation Service has been helpful in selecting plant materials. Grasses developed in these programs were directed toward production agriculture, so they are readily available commercially.

Native grasses are planted as simple mixtures. These mixtures are designed from observation of native stands and performance by individual species rather than on matrix energetics. Most of our mixtures contain four or five seed components including one or more species that has rapid germination and good seeding vigor for early cover. Since we are not interested in production we believe that the dynamics of the stand will determine the relative abundance of each component.

The emphasis on restricted mowing coupled with the dissatisfaction with soil sterilant herbicides points up an opportunity to use low-growing grasses in critical areas such as under guard rails. It has long been known that plants such as sideoats grama native to more northern regions and responsive to photoperiod are stunted when grown in more southern areas. These have become little more than a curiosity in nurseries where production is an objective, but they offer a possibility for field installation plantings where shorter plants are desirable.

Our present efforts are aimed at identifying and developing propagation technology for other plant growth forms to use for roadside planting in each of the 10 natural plant regions of Texas. We have briefly examined the propagation requirements for forbs, and 6 of the 25 most-wanted species were easy to grow. Seed is still relatively expensive, and this has forced careful site selection for installing plantings of these materials. Our emphasis now is shifting to the propagation of shrubs and trees for roadside use. We have enlisted coworkers in horticulture in this study. Further, we plan to test local adaptation of plant materials in strategic test centers prior to installing in field plantings.

We expect plant materials to fill the following niches:

1. Exhibit sufficient adaptability to perform well on soil textures ranging from sandy to clay as well as on north- and south-facing slopes.

2. Accommodate the stresses of harsher habitats such as saline or acidic soils, urban environments, or soil materials uncovered in construction.

In summary, the vegetation management system of the Texas State Department of Highways and Public Transportation emphasizes native plants for both functional and accent use. Good progress with grasses has been made, but much remains to be done with other plant forms. It is hoped the experience gained with grasses will help us accelerate the development of additional planting materials.

Native plant materials are being accepted and used by landscape architects as low-maintenance plantings. More importantly, a landscape need for specific plant materials to use in a particular situation presents a challenge to persons involved in developing plant materials. Many plants from production agriculture can and have been used, but demands for certain materials may broaden considerably the spectrum and variety of plants we study and offer commercially. Roadside needs parallel those in mine-spoil reclamation in many ways, and represent a deviation from traditional range thinking where a primary attribute is biomass production.

Plants for Western Colorado, Eastern Utah, and Southwest Wyoming

By Sam Stranathan, Upper Colorado Environmental Plant Center, Meeker, CO

Two years ago in Albuquerque many of you saw, for the first time, 'Rincon' fourwing saltbush (*Atriplex canescens*).

The Forest Service Shrub Lab, headed by Dr. Durant McArthur, initiated some revolutionary concepts in fourwing selection and production with 'Rincon'. First, 'Rincon' is a mixture of six separate female lines and four male lines. These lines are maintained as 'Rincon'. A proportionate number of males and females are used to establish new orchards. The seed harvested from these controlled orchards is classed as Certified 'Rincon'.

So today it is a ligitimate question to ask, "Where's the 'Rincon' "?

The Plant Center, in cooperation with the Forest Service Shrub Lab and cooperating State seed certification agencies in Colorado, Utah, Idaho, and Wyoming, has shipped thousands of male and female 'Rincon' plants to growers. 'Rincon' orchards now exist on about 20 acres.

Growers picked some seed in 1984. Seed is available in limited quantities. Our grower success has not been 100 percent. A grower begins with the best of intentions only to find he didn't allocate enough resources to the project. Common problems have been improper planting, weed control, timely watering, and isolation maintenance. Any one or a combination of these factors has decreased yields and slowed seed production down by as much as a year. Growers are a most important cog in the success of any new plant material product.

We continue to be excited about the direct seeding performance of 'Rincon'. Spring seeded plants at the 7,000-foot site near Milner, CO, are well established, standing 6 to 10 centimeters tall at 3 months of age. 'Rincon' direct seeded in early spring on a drier site at 5,000 feet elevation in the Piceance Basin of western Colorado were 20 to 30 centimeters tall as 4-month-old plants.

In 1984 the Meeker Plant Center released a slender wheatgrass named 'San Luis'. This *Agropyron trachycaulum* is to be used primarily on disturbed sites at higher elevations. These sites will often be associated with transmission corridors, roads, trails, and ski slopes. It was selected for its performance on high altitude sites associated with hard rock mining where it displayed longer than average life span.

Seed went to growers in 1984 but production has been slow. We are going to work harder to get this worthwhile grass moving on the market.

We have had a great challenge in our attempts to select a top performing Louisiana sage (*Artemisia ludoviciana*). Working closely with Steve Monsen of the Forest Service Shrub Lab we scrutinized about 30 different types and compared field performance from many sites throughout Colorado, Utah, and Idaho.

Based on good performance at some pretty tough planting sites a strongly spreading type of Louisiana sage was selected for the first ecotype to be released. It is named 'Summit'.

Since 'Summit' was just released in November, seed and sprigs will be going out to growers this spring. It is not anticipated that many acres will be needed to meet the market demand.

Thanks to Dr. Doug Dewey and Dr. Kay Asay of Logan, Utah ARS shop and the Soil Conservation Service, the district owned Plant Center at Meeker is growing the hottest new Crested wheatgrass since 'Nordan'. This *Agropyron desertorum-Agropyron cristatum* cross called 'HYCREST' has a track record that is quite exciting. As with any new product that has seemingly instant success the demand for seed outruns the supply.

We produced 400 pounds of Foundation seed on 1 acre this year and seed was distributed to Montana, Wyoming, Utah, Idaho, and Colorado. We have increased our field size and anticipate raising 1,200 to 1,600 pounds of Foundation seed in 1985. This seed will be available for spring seedings in 1986.

These new plants are actually new products for agriculture. They provide a few farmers the opportunity to diversify their production and impact their income favorably. This seems important to us. Agriculture is having a very difficult time making ends meet. For those that can be successful at producing plant materials and certified seed, the new plant materials products can be a valuable asset.

Recent Plant Releases For Western Wildlands[1]

By Richard Stevens, Utah Division of Wildlife Resources, Ephraim UT; Stephen B. Monsen, Forest Service, Provo, UT

Recently, some useful broadleaf herbs and shrubs have been released for range and wild land plantings. These items have been under study for over 25 years and provide additional species useful for planting disturbed wild lands. This is a report of the features, uses, and areas of adaptation of three more recently released cultivars. More specific information of each selection is available from any of the cooperative agencies involved in the release program.

'Hatch' Winterfat (*Ceratoides lanata*)

'Hatch' winterfat has been selected for its ability to establish, persist, and provide forage diversity and winter herbage in the sagebrush and pinyon-juniper communities (fig. 1). Big game and livestock prefer 'Hatch' over other tested accessions. The species is an erect, half-shrub (up to 4 feet tall) that furnishes an abundance of available winter forage, particularly in years and areas of heavy snow accumulation. 'Hatch' has also been successfully seeded on mine disturbances and other harsh sites.

Figure 1.—'Hatch' winterfat.

'Hatch' is a high seed producer with good germination. Excellent seedling vigor contributes to its ease of establishment. Seedlings grow rapidly; consequently, this shrub can be seeded with various broadleaf herbs and grasses. Site preparation for planting is minimal, and seed can be broadcast or drilled. With either, practice seed should be placed on or near the soil surface. Seedlings tolerate light grazing from rodents, livestock, or wildlife. The plant has an upright growth habit, is leafy with moderately fine stems, and produces an abundance of forage and seed. Basal leaves persist through the winter, providing some evergreen herbage. 'Hatch' is considered an "ice cream" plant and is used highly by wildlife and livestock.

Seed was originally collected by A. Perry Plummer in 1953 from a native stand one-fourth mile northwest of the Mammoth Creek fish hatchery, southwest of Hatch, UT. This site is at an elevation of 7,270 feet within a mixed pinyon-juniper and mountain big sagebrush community, with an annual precipitation of 11 to 12 inches.

'Hatch' originated on a medium-textured soil but has proven to be well adapted for heavy soils to fine sandy loam soils. It is adapted to neutral and slightly alkaline sites and is particularly adapted to infertile mine spoils. It is not well suited to soils or sites with less than pH 6.5. Its rapid growth rate has made the plant useful for stabilizing windblown soils and extensive barren sites caused by wildfires. 'Hatch' may not persist on poorly drained soils and sites having a shallow impervious horizon. The species is best adapted to areas of 12 to 16 inches annual precipitation, but once established it will persist with only 8 inches. 'Hatch' has excellent winter hardiness and drought tolerance, but seedlings may be damaged by frost.

'Hatch' has established and persisted better and on a wider range of sites than any other tested winterfat accession when planted in Wyoming and basin big sagebrush types and the pinyon-juniper communities. It is best adapted to open, sunny exposures and is only moderately shade tolerant. 'Hatch' will not persist on occasionally flooded areas or sites with a high water table. It has been tested in Utah, New Mexico, Nevada, Wyoming, Idaho, Colorado, Arizona, Montana, and Oregon. In most or all cases it has proven equal or superior to other tested accessions.

'Hatch' was jointly released by the Forest Service Intermountain Research Station; Soil Conservation Service; Utah Division of Wildlife Resources; and agricultural experiment stations in Utah, Idaho, New Mexico, and Colorado.

Breeder, foundation, and certified seed classes are recommended. Breeder plants are being maintained at the Los Lunas Plant Materials Center, Los Lunas, NM. Foundation seed is being produced by the Los Lunas Center and the Aberdeen Plant Materials Center, Aberdeen, ID. Foundation seed may be obtained from crop improvement associations, agricultural experiment stations, and soil conservation districts.

'Cedar' Palmer Penstemon (*Penstemon palmeri* var. *palmeri*)

'Cedar' Palmer penstemon (fig. 2) was selected for its ability to establish, persist, and provide forage diversity when seeded in mixtures on winter, spring, fall, and summer game and livestock ranges in the pinyon-juniper, big sagebrush, black sagebrush, mountain brush, and bitterbrush communities. It produces a considerable amount of succulent foliage during spring and summer. A high percentage of the basal leaves also remain green during winter, providing high quality forage during this critical period. Small birds, big game, and livestock seek out 'Cedar'. It provides good ground cover for erosion control and stabilization of disturbed sites and burns.

[1]Funds provided by Federal Aid in Wildlife Restoration, Project W-82-R.

Figure 2.—'Cedar' Palmer penstemon.

It is also useful for horticultural and landscape plantings because of the abundant flowers, pleasing aroma, and persistent green foliage.

'Cedar' is an evergreen native perennial with a thick fibrous tap root. Long (up to 4 feet), erect flowering stalks arise from a thick crown. Large pink to lavender-pink blossoms with red-violet throats occur along the stalks, persisting for several weeks in late spring and early summer. Flowers give off an unusual and pleasant fragrance that is not found in some other penstemon species. An abundance of seed matures in mid-August after which the flowering stalks dry.

The original collection of 'Cedar' was made in 1939 by A. Perry Plummer from a native stand approximately 15 miles west of Cedar City, UT. The selection occurs throughout a mixed pinyon-juniper, big sagebrush community at an elevation of 5,800 feet that received 9 to 12 inches of annual precipitation.

The original collection of 'Cedar' came off a gravelly loam soil (Hiko Peak). The species has, however, proven well adapted to heavy, fine sandy loam, and rocky soils ranging from slightly acidic to strongly alkaline. It is well adapted to infertile, disturbed soils. 'Cedar' is best adapted to areas receiving 10 to 16 inches annual precipitation, but once established, it will persist on sites receiving as low as 8 inches of annual precipitation. Seedlings and mature plants have excellent winter hardiness and drought tolerance. Seedlings are well adapted to mixed plantings and compete successfully with most herbaceous species.

Original plantings were in Utah but subsequently extended to sites in Idaho, Montana, Wyoming, Nevada, Colorado, New Mexico, Arizona, and Oregon. 'Cedar' has also been evaluated for use in revegetation of mine spoils and disturbed areas within the Intermountain region.

Mature plants are 5 to 7 years old—long-lived for penstemons. Extensive regeneration can occur by natural seeding. An abundance of seed is normally produced even during adverse years. Seed may persist in the soil for several years, allowing for natural spread and stand maintenance. 'Cedar' does best in open stands but will grow in association with grasses, low shrubs, and intermediate shrubs such as big sagebrush and antelope bitterbrush. 'Cedar' is subject to some diseases associated with alfalfa and potatoes, particularly on heavy, poorly drained soils.

'Cedar' was jointly released by Utah Division of Wildlife Resources; Forest Service Intermountain Research Station; Soil Conservation Service; and agricultural experiment stations of Utah, Idaho, New Mexico, and Colorado.

Breeder, foundation, registered, and certified seed classes are recommended. Breeder seed is being maintained and foundation seed will be produced at the Los Lunas Plant Materials Center, Los Lunas, NM. Breeder or foundation seed may be obtained from crop improvement associations, agricultural experiment stations, and soil conservation districts.

'Immigrant' Forage Kochia (*Kochia prostrata*)

'Immigrant' forage kochia (fig. 3) was selected for its ability to establish and persist in the pinyon-juniper, sagebrush-grass, and salt desert shrub types. It has good potential as a year-round range forage crop and for erosion control and critical area treatment.

'Immigrant' is a semievergreen subshrub or small shrub to 3 feet tall. It has excellent forage quality in spring and summer but somewhat less in winter. Sheep, deer, and cattle find it palatable. Upland game birds make use of it as a cover and food source. 'Immigrant' has good resistance to grazing. The lower third of the plant remains green throughout most of the year. Grazing animals will paw through snow to graze the green base. The upper stems and seed stocks turn red in the fall and dry after seed shatter (October through November).

Figure 3.—'Immigrant' forage kochia.

'Immigrant' has performed well in low to intermediate rainfall areas receiving 5 to 27 inches of annual precipitation. It grows well on disturbed sites, on mineral soils, and in competition from weedy species, including halogeton, cheatgrass, and Russian thistle. 'Immigrant' seeds germinate in late February and early March and can develop 10 to 18 leaves before halogeton starts to grow. It outcompetes many annuals and fills in the interspaces between perennial plants.

Additional important characteristics exhibited by 'Immigrant' are the ability to establish and persist on disturbed harsh soils, fairly high salt and drought tolerance, tolerance to temperature extremes (-25 to 104°F), low oxalate levels (lower than winterfat and fourwing saltbush), ability to spread rapidly from seed, high seed production, moderate shade tolerance, and fair fire tolerance.

Throughout the Intermountain West 'Immigrant' has done well in basic soils but has performed poorly in neutral and acid soils. It grows well on soil textures ranging from sandy loam to heavy clay, but it does especially well in heavier soils. Areas of best adaptation are in greasewood-shadscale, basin big sagebrush, Wyoming big sagebrush, and pinyon-juniper communities.

'Immigrant' was introduced into the United States from Russia in 1966. Seed was produced by the Pullman Plant Introduction Station, Pullman, WA, in 1967 and sent for testing to State and Federal experiment stations, plant material centers, and universities. At least 18 accessions of *Kochia prostrata* have been evaluated. 'Immigrant' has been the superior performing accession in experimental seeding trials, rangeland seedings, and on mine spoils and disturbed areas in Utah, Idaho, Nevada, Oregon, Arizona, New Mexico, and Wyoming. Of all the forage Kochia accessions, 'Immigrant' has demonstrated superiority in forage production, forage quality, palatability, and aggressiveness toward annuals. Individual plants are still living after 14 years.

'Immigrant' forage kochia was jointly released by Utah Division of Wildlife Resources; Forest Service Intermountain Research Station; Soil Conservation Service; and agricultural Experiment stations of Utah, Idaho, Oregon, and Nevada.

Recognized classes of seed will be breeder, foundation, registered, and certified. Breeder plants are being maintained by the Aberdeen Plant Materials Center, Aberdeen, ID. Registered seed will be available through local soil conservation districts, agricultural experiment stations, and crop improvement associations of Idaho and Utah.

Seed Harvesting

Stephen B. Monsen, *Chairman*

Seed Harvesters--An Evaluation of Existing Machines and Projected Needs[1]

By Stephen B. Monsen, Forest Service, Provo, UT; Richard Stevens, Utah Division of Wildlife Resources, Ephraim, UT; Kent R. Jorgensen, Utah Division of Wildlife Resources, Ephraim, UT

Since the mid-1960's studies have been under way to develop seed harvesters capable of collecting seeds of different native shrubs and herbs. Harvesters are needed that can be operated on wild land sites, cultivated fields, seed orchards, or nurseries. Numerous native species are currently being marketed for range and wild land restoration projects. To date, most seeds have been hand collected from wild land stands. Seed costs are often quite high, and an inadequate supply of good quality seed frequently occurs. Seeds of many species can and are being grown in nurseries, yet costs remain high as mechanical harvesters are not available from seed collection.

Various seed collectors and related equipment have been modified and used to collect seed of different shrubs and herbs. Field combines, air blowers, and suction machinery have been tested or used to collect certain seeds. No single item of equipment is suitable for harvesting seeds of all species. Numerous types of fruits or seeds are produced, including berries, seeds with wings or hairy appendages, and very small seeds.

Because of seeds of most native species have been harvested from wild land stands, emphasis was initially directed toward the development of backpack units or vehicle-mount units that could be operated under field conditions. Most of the first machines developed or tested were suction operated, drawing seed into the machine with air intake hoses. These machines were designed to collect lightweight seeds that could be easily dislodged from the plant. Two features were of primary concern with these harvesters: (1) sufficient suction to extract and draw seeds into the collectors, and (2) a bypass system whereby seeds were not damaged when drawn into the harvester. Information presented in table 1 summarizes the features and operational capacity of the nine collectors that have been most widely tested.

Table 1.—*Type and features of seed collectors*

Characteristics	Truck mounted	Jeep mounted	MecTighe backpack	D.S.I.* backpack	Air amplifier	Echo PB400 blower	Solo power blower	Insect collector	Elephant Vac
Weight	1 ton	900 lb	44 lb	44 lb	12 lb	22½ lb	24 lb	20 lb	370 lb
Travel mode	2-ton truck	Jeep	Man	Man	collector=man compressor=pickup	Man	Man	Man	Pickup truck
Travel restrictions	Level terrain	Level terrain	Where man travels	Where man travels	Level terrain	Where man travels	Where man travels	Where man travels	Level terrain
Number of operators	3	3	2	2	2	1	1	1	2
Hose inlet size (inches)	3-8	3-6	3-4	3-4	4-8	2½	1½	6	6
Hose length (feet)	30	25	3	3	collector=5 compressor=50	3	3	2½	30
Number of hoses	2	2	1	1	1	1	1	1	1
Size of seed containers	2-2 bu bags	2 bu bag	1 bu bag	1 bu tank	2 bu bag	1 bu bag	1 bu bag	1/8 bu	4 bu tank
Air velocity (feet per minute)	7,000+	7,000	7,000	7,000	?	7,000+	7,000+	?	1,000+
Seeds move through impellor	No	Yes	No	No	No impellor	No	No	No	No
Source of power	Gas motor	Gas motor	Gas motor	Gas motor	Compressor	Gas motor	Gas motor	Gas motor	Gas motor
Harvesting capabilities									
Plumed seeds[1]	2[2]	2	3	3	3	3	3	3	2
Berries	4	4	4	4	4	4	4	4	4
Winged fruits	2	2	3	3	3	4	4	4	2
Large seeds	3	3	4	4	3	4	4	4	3
Small seeds	1	2	2	2	2	3	3	3	2

[1]Plumed seeds = Apache plume, aster, rabbitbrush; berries = chokecherry, serviceberry, hawthorn; winged fruit = fourwing saltbush, maple; large seeds = bitterbrush, green ephedra; small seeds = sagebrush, grasses.

[2]Rankings: 1 = perficient, 2 = well adapted, 3 = moderately adapted, 4 = inadequate.

*D.S.I. = Developmental Sciences.

[1]Funding provided through Pittman-Robertson Wildlife Restoration Project W-82-R.

To date, need still exists for a versatile backpack collector that can harvest lightweight seeds. Both the prototype units, developed in the early 1970's, have desirable features, yet require further improvements. In addition, large self-propelled harvesters are also needed to harvest field-grown seeds and seeds from nursery sites. In 1984, we conducted a survey to better determine equipment needs and the type of seeds being harvested. In addition, we determined the seeds that are in demand but are not being supplied due to the lack of adequate seed harvesting equipment.

The survey indicated that 75 percent of the 30 individuals that responded to the survey acquired native shrub and broadleaf herb seeds from both wild land stands and cultivated fields. Of all users, 12 percent obtained seeds only from wild land collections, whereas 6 percent acquired seed only from cultivated fields or nurseries. Over 50 percent of all shrub seeds currently being sought or used are from a group of 12 to 15 species (table 2). Nearly 90 percent of all users dealt with fourwing saltbush (*Atriplex canescens*). Other species of universal importance included in descending order of importance: winterfat (*Ceratoides lanata*), rubber rabbitbrush (*Chrysothamnus nauseosus*), antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), serviceberry (*Amelanchier alnifolia*), and snowberry (*Symphoricarpos oreophilus*). If species are ranked in order of the amount of seed sold or used, the listing changes somewhat (table 2). Fourwing saltbush remains number one, followed in order by big sagebrush, antelope bitterbrush, rubber rabbitbrush, and winterfat. Although user groups require seeds of species such as chokecherry (*Prunus virginiana*), mountain-mahogany (*Cercocarpus* spp.), eriogonum (*Eriogonum* spp.), serviceberry, and Woods rose (*Rosa woodsii*), a large amount of seed is not currently being dispensed. These species represent seeds that are more difficult to collect from wildland sites or are produced from cultivated fields.

The survey also determined that fleshy berries were the most difficult type of fruit or seed to harvest and process (table 3). Seeds acquired from the *Compositae* family (rabbitbrush, aster, etc.) were the next most difficult, followed by extremely small seeds (sagebrush, alder, eriogonum).

Most survey respondents concluded that seed harvesting equipment was urgently needed to accommodate the collection of fleshy berries (table 3). Listed in descending order of importance were machines capable of harvesting fleshy berries, plumed seeds (Compositae), large size achenes (bitterbrush, cliffrose, mahogany), small seeds, dry berries (*Ceanothus*, sumac), winged seeds (saltbush, ash, hopsage), and dry fruits (*Penstemon*, cinquefoil).

Table 2.—*Principal species of native shrubs being marketed or used as seed*

Species	Utility: Percent of all groups that utilize the species	Ranking: Order of importance
Atriplex canescens (fourwing saltbush)	88	1
Artemisia tridentata (big sagebrush)	62	2
Purshia tridentata (antelope bitterbrush)	62	3
Chrysothamnus nauseosus (rubber rabbitbrush)	69	4
Ceratoides lanata (winterfat)	81	5
Cercocarpus (mountain-mahogany)	56	6
Amelanchier alnifolia (serviceberry)	62	7
Prunus virginiana (chokecherry)	56	8
Symphoricarpos oreophilus (snowberry)	62	9
Kochia prostrata (forage kochia)	56	10
Sambucus cerulea (blueberry elder)	43	11
Eriogonum (buckwheat)	56	12
Rosa woodsii (Woods rose)	50	13
Cowania mexicana stansburiana (cliffrose)	37	14
Rhus (sumac)	31	15
Ceanothus (buckbrush)	18	17
Ephedra (Mormon tea)	31	18

Other important species: *Acer glabrum, Alnus tenuifolia, Atriplex confertifolia, A. gardneri, Grayia spinosa, Peraphyllum ramosissimum, Prunus fasciculata, Ribes, Sorbus scopulina.*

Table 3.—*Ranking of seed collectability and seed harvesting equipment needs*

Seed or fruit categories	Ranking Difficulty of collection	Ranking Harvesting equipment needs
Category 1—Pods (dry fruits) *Penstemon*, leadplant, cinquefoil	7	7
Category 2—Composites (plumes) rabbitbrush, *Clematis, Aster*	2	2
Category 3—Winged seeds maple, saltbush, ash	5	6
Category 4—Berries (fleshy) serviceberry, chokecherry, currant	1	1
Category 5—Berries (dry) *Ceanothus*, sumac, hawthorn	4	5
Category 6—Achenes (small dry seeds) alder, sagebrush, *eriogonum*	3	4
Category 7—Achenes (large dry seeds) mountain-mahogany, bitterbrush, cliffrose	6	3

Rankings 1-7, 1 = highest.

The survey revealed several important points:

1. Most native shrub seeds currently in demand involve 12 to 15 species. Some have similar seed characteristics and could be harvested with similar equipment. Different machinery will be required to collect the various types of fruits or seeds, yet a large number of machine harvesters do not appear to be required.

2. Seeds are currently being acquired from both wild land stands and cultivated plantings. A general shift toward cultivated fields or nurseries appears to be developing. Large amounts of seed can be produced from cultured stands. Consequently, seed harvesters that are adapted to cultivated fields are gaining importance. Backpack collectors or units designed to harvest seed from wild land sites remain important, because field-grown crops cannot fully substitute for wild land collections.

3. Some species, although somewhat difficult to collect, are still sold in large volumes due to market demand and prices. This group includes rabbitbrush, winterfat, and some species of saltbush. In contrast, seeds of other species, although in demand, are not being marketed due in part to seed harvesting difficulties. Seeds of serviceberry, mountain-mahogany, and Woods rose are examples. The development of seed harvesters would greatly enhance the collection and use of these items.

4. The development of seed harvesting equipment could have dramatic impacts upon seed sales and uses if specific machines were available.

5. The development of a berry harvester is ranked as the number one priority for research investigation. These seeds are difficult to hand collect, yet users recognize that significant accomplishments could be achieved with minimal research.

6. Even though a considerable volume of plumed seeds (composites) and large dry seeds (achenes) are currently being hand collected, these are ranked as the next two seed groups for which seed harvesters are needed. Small seeds and winged seeds are listed in descending order of importance.

Sufficient funds have not been available during the past few years for equipment development projects. Some research has continued with backpack harvesters and machines capable of collecting fourwing saltbush. Research will likely continue with these two types of harvesters. Modifications and improvements have been achieved with some field combines, as native forbs and shrubs are being grown in cultivated fields. This activity will undoubtedly continue and will likely result in some major improvements in seed harvesting.

Fourwing Saltbush Seed Harvester Development--Progress Report

By J.L. Halderson, University of Idaho, Aberdeen, ID;
C.G. Howard, Soil Conservation Service, Aberdeen, ID

Introduction

Fourwing saltbush, *Atriplex canescens* (Pursh) Nutt. is a native, dioecious shrub widely adapted to the semiarid desert and foothill rangelands in Western North America. The plant is very salt-tolerant and is nutritious browse for wildlife and livestock. Seed of proven varieties is much needed for use in revegetating decimated rangelands and disturbed areas such as mine spoils and roadsides.

Under favorable conditions, the female plants produce an abundance of seed called utricles which have four membranous wings. The plant is semievergreen and seed maturation occurs in the Aberdeen, ID, area between October 15 and November 15, depending on the climatic conditions occurring during a specific growing season. Utricles turn brown and shatter readily when fully mature. To date, the only known method of harvesting the seed is by hand. This is slow and costly. The personnel at the Bridger, MT, Plant Materials Center (PMC) successfully harvest utricles of the subspecies *aptera* with a conventional combine. However, the *aptera* is not well adapted to this region, especially in an irrigated seed orchard. The conventional combine is not well suited for harvesting other *A. canescens* accessions because of the large number of woody stems and the abundance of green vegetation at harvest time.

An improved cultivar of fourwing saltbush with the name "Rincon" has been released by several Western States, the Forest Service, Soil Conservation Service, and the Utah Division of Wildlife Resources. A procedure for planting seed orchards developed by Dr. Durant McArthur was used in planting seed orchards at the Meeker, CO EPC and the Aberdeen, ID, PMC. Dr. McArthur's method provides proportioning of female plants to male plants to ensure maximum pollination and subsequent seed production. The Aberdeen orchard was planted in early 1983 primarily to provide a place to test experimental harvest machinery, and it should provide a good seed crop in 1985.

The seed orchard at Aberdeen is approximately 5 acres in size and contains the "Rincon" variety. Little seed was available in the orchard in the fall of 1984 because the plants were only 18 months old and the winter of 83 to 84 was one of the most severe on record for the area. Therefore, harvester evaluations were conducted at Bliss, ID.

During November of 1984, seed harvesting trials were conducted near Bliss to evaluate three harvesting methods. Mature fourwing saltbush plants, with an abundance of mature seed, were found along the interstate highway right-of-way. These plants were the result of dry seeding of drillbox mixture of seeds in the early 1970's. The plants had considerable variation in seed maturity, were intergrown with weeds and had considerable dead wood around the skirt of the plant (fig. 1). The site did not entirely represent orchard conditions but provided useful preliminary information for development of a seed harvester.

Figure 1.—Fourwing saltbush with mature seed at Bliss, Idaho (November 1984).

Experimental Conditions

Experiments at Bliss included: (1) hand harvesting, (2) vacuum harvesting, and (3) shakers with catching aprons. The Elephant Vac and an Echo PB 400E backpack machine were used along with a Homelite shaker originally developed for small tree fruit harvesting. Where conditions permitted, four replications of 1 hour each were completed for each harvesting system. Shakers were tested to determine the effectiveness of seed removal, production rate, compatibility of aprons with bush growth habits, and the physical effects of the shaker clamp upon the bush. Collection aprons were tested for best configuration, seed collection influences, and suitability of materials of construction. Vacuum machines were tested for effectiveness of seed removal, production rate, and performance of collection hoses. Hand harvesting was used to determine a base value to which mechanical harvesting production rates could be compared.

Results

Combine.—Direct combining of two rows of female plants in the Aberdeen seed orchard was tried in late October, although there was very little seed production. Low cylinder speeds (rasp bar type) and open cylinder clearance from the concave gave good seed threshing.

Seed separation in the combine could not be achieved because the green, heavy leaves and "straw" carried the light, dry seeds through the straw walkers, sieves, and cleaning shoes. Everything was conveyed through the combine to form a windrow behind it. Increasing sieve clearance caused leaves to fall through and go to the grain tank. Effective separation in the field does not appear promising when seed is harvested at this time of year.

Vacuums.—The performance of the Elephance Vac (fig. 2), operating at 7.3 in (H_20) vacuum at the nozzle end of the hose, was not satisfactory for completion of four replications. Removal rates were very low and small twigs readily bridged across the 8-inch-diameter collection hose. Removal of seed was considered insufficient even from plants which were harvested quite readily by hand. The Elephant Vac appears unsuited for orchard harvesting of fourwing saltbush seed. It could be useful in seed collection from aprons if a smooth-walled hose is obtained to replace the present ribbed hose. This change should greatly reduce or eliminate bridging. The Echo vacuum is considered unsuitable either for saltbush seed harvesting or for collecting of seed from aprons.

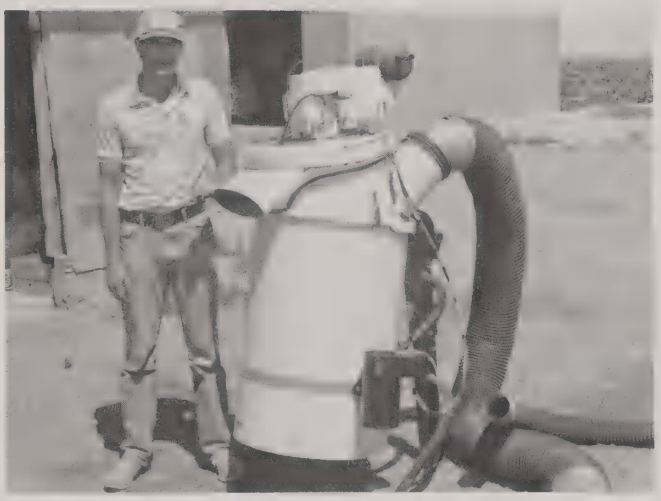


Figure 2.—The Elephant-Vac vacuum machine used in seed harvesting experiments on fourwing saltbush.

Shakers.—Shakers (fig. 3) averaged 8.9 lb/man-hour of raw seed as compared to 11.8 lb/man-hour for hand harvesting. Shakers required more physical effort than hand harvesting. Under conditions of a seed orchard, harvesting rates from shakers could be expected to increase whereas hand harvesting rates would likely remain relatively constant. The clamp gave evidence of considerable bark removal in certain instances. Long-term plant damage effects will need to be assessed. Under certain conditions, all seeds were removed from a particular branch within a second or so after shaking commenced. In other instances, shaking for 5 to 10 seconds was required to maximize removal.

Catching aprons (fig. 4) are 5 feet wide by 10 feet long and are constructed from 2-inch-square aluminum tubing with a 3 mil woven polyethylene covering. At the Bliss site, aprons were not easy to position because of several factors. Dead wood, unpruned plants intermingled plant types, and random saltbush plant locations restricted placement. Some of these problems would normally be eliminated in seed orchard operations. Apron material seemed quite satisfactory as it is lightweight, readily kept taut, is relatively puncture resistant, and can be readily patched.

Wind sometimes blew seed off the aprons. Equipment will have to be designed to operate during some amount of wind as conditions in an open seed orchard will probably amplify any wind-related problems. Rectangular shaped catching aprons, operated in pairs, are not sufficient to catch all the seed shaken from a bush. The opening between aprons was covered with a light tarp at Bliss. This improved total seed collection but probably did not increase the harvesting rate because of the time required to handle the tarps.

Pruning of the bush appears highly desirable for facilitation of shaker operations. Pruning would minimize the diameter of the circle of trunks emerging from the ground and remove the branches which touched the ground. Catching aprons could then be placed in a quicker and easier manner and the opening between the inside edges of the two aprons could be reduced or eliminated.

Conclusions

While harvester experiments in the fall of 1984 gave beneficial information, they were not tested in a seed orchard so direct comparability could not be done. Vacuums of any size appear to lack power at the nozzle for authoritative seed detachment. Shaker performance can definitely be improved, and they could be adequate as a replacement for hand harvesting. If shaker development can progress to a sufficient degree, it could lead to a self-propelled, over-the-row type harvester. Combines appear unsuited for direct cut harvesting while leaves are still green and heavy. Windrowing or later direct cut harvesting give promise of improved results since seed-straw separation would be facilitated.

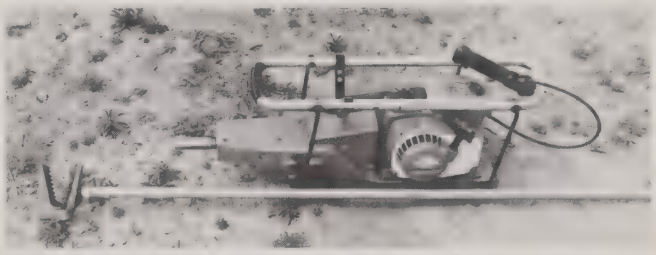


Figure 3.—Homelite shaker used in seed harvesting experiments on fourwing saltbush.

Figure 4.—Aprons with woven polyethylene covering used for catching fourwing saltbush seed from shakers. Apron size is 5 ft. by 10 ft.

Disturbed Land Reclamation
(Western Subgroup)

James L. Smith, *Chairman*

Reclamation Equipment and Techniques in Southwestern Wyoming

By Fred E. Parady III, Bridger Coal Co.,
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Abstract
Bridger Coal Co operates a surface coal mine 35 miles northeast of Rock Springs, WY. Approximately 20,000 acres are under permit, with disturbance over the life of the mine projected to reach 10,000 acres. Located on the western rim of the Continental Divide, the mine receives less than 9 inches of precipitation annually. Soils in the area are coarse-textured, and problems associated with elevated salinity and sodicity are encountered.

A variety of common reclamation techniques have been modified to reflect these conditions. Soil horizons are segregated during salvage operations (the surface 6 inches topsoil and the balance as subsoil). Unsuitable materials are not salvaged. Direct application of soil is used to maximize native plant regeneration and conserve soil fertility. Interseeding of seeding failures has proven to be significantly more successful than chisel plowing and reseeding. Broadcast seeding has been ineffective because of strong winds, and a no till drill has been modified to handle diverse seed mixes and rock conditions. The utility of fertilization under typically xeric moisture regimes is being evaluated.

Introduction
Bridger Coal Co. mines from 4.4 to 6.8 millions tons per year of subbituminous steam coal at its surface strip mine 35 miles northeast of Rock Springs in southwestern Wyoming. The mine is adjacent to the Continental Divide at elevations ranging from 6,800 to over 7,100 feet. Mean annual precipitation is 8.79 inches, and the average number of frost free days is 100 (Bridger Coal Co. 1980). Bridger's permit to mine encompasses nearly 20,000 acres, with 3,873 acres disturbed and over 1,030 acres (or 27 percent) reclaimed to date (Bridger Coal Co. 1984). Life of mine disturbance is projected to reach approximately 10,000 acres.

Reclamation feasibility in southwestern Wyoming has been questioned since the resurgence of the coal mining industry in the early 1970's. The National Academy of Sciences (1974) suggested that 10 inches of precipitation was necessary to sustain revegetation efforts. Bridger coal has developed or modified a variety of reclamation equipment and techniques to reflect local conditions and provide the foundation for successful reclamation. The following information is based on observations during the past four growing seasons.

Soil Management
Soils on the mine site are typically Entisols or Aridisols, coarse textured, with an average pH of 7.5 to 8.0 and electrical conductivity in the 4.0 to 6.0 mmho/cm range. Problems associated with elevated salinity, sodicity, and boron levels are encountered. Bridger Coal has implemented a soil management program to assure that the best use is made of soil resources.

First, a staking program is used on the highwall to identify unsuitable native soils. Unsuitable materials should not be moved onto recontoured spoil unless soil heterogenity is specifically desired. During soil stripping operations, soil horizons are segregated (the surface 6 inches as topsoil and the balance as subsoil). Soils range from 6 inches to 60 inches in depth, with a mine wide average of 15 inches. Revised permit language has been submitted to the State to allow for variable soil application depths. Variable soil depths provide a component of diversity. Stripped soil is either stockpiled or hauled directly onto a completed regraded area. Stockpiles are recontoured to allow farming operations on the side slopes and to minimize erosion.

Direct application of soil is a key element in achieving diversity elements of bond release criteria. Soil is picked up with scrapers and transported across or through the pit and dumped directly on ripped recontoured spoil. Bridger Coal initiated direct application of soil in 1976, and has succeeded in using this preferable method on all areas reclaimed in the last 2 years, a total of 230 acres. The increased cost of longer hauls associated with direct application is offset by elimination of double handling incurred by stockpiling. This technique maximizes native plant regeneration and conserves soil fertility. Bridger Coal has also completed soil application to 175 acres using stockpiled material as a subsoil covered with a 6 inch surface application hauled directly from the highwall.

Specifically, 10 species have volunteered from direct applied soil. These species include big sagebrush (*Artemisia tridentata*), Sandberg's bluegrass (*Poa sandbergii*), Fendler's bluegrass (*Poa fendleriana*) greasewood (*Sarcobatus vermiculatus*), rubber rabbitbrush (*Chrysothamnus nauseosus*), plains wallflower (*Erysimum asperum*), scarlet globemallow (*Sphaeralcea coccinea*), and scarlet gilia (*Ipomopsis aggregata*). Direct application of soil aids in returning the shrub and forb components of the plant community, as well as establishing understory species of the grass component.

Farming Operations

The goal of reclamation is set by statute under the Surface Mining and Reclamation Act of 1977 to establish a diverse, native plant community capable of regenerating itself. Diverse techniques must be employed to achieve diversity of species in a reclaimed plant community. Seed drills used initially in reclamation, specifically the Laird rangeland drill, were not capable of handling fluffy, trashy native seeds such as winterfat (*Ceratoides lanata*). Consequently, only five or six species were seeded in early reclamation efforts, generally wheatgrasses and fourwing saltbush.

To remedy this, Bridger Coal Co. purchased a Tye "Pasture Pleaser" no till seed drill. The drill has three seed boxes, with fairly standard wheatgrass and legume boxes. The third, a shrub box, is specifically equipped with agitator disks and larger picker wheels to handle trashy seed. In addition, the large seed tube from this box can be left unbolted from its brackets, distributing seed across the entire furrow. The result is variable planting depths, including shallow planting depths that are desirable for most of these species. Bridger Coal has therefore been able to use 18 to 20 species in each of its 4 seed mixes: shallow loamy, sands, saline upland, and saline lowland. Big sagebrush (*Artemesia tridentata*) was successfully established with this technique in a fall 1983 seeding. Although such results have not yet been duplicated, they are encouraging. Studies by DePuit and Coenenberg (1979) have indicated that increasing the number of species in a seed mix increases the diversity of the resulting plant community.

An additional technique that has proven successful during the last 3 years is interseeding. Interseeding involves seeding with a no till drill directly into an existing reclaimed surface, rather than chisel plowing and reseeding. The advantage lies in minimizing disturbance to the soil and in keeping existing vegetation intact. During the fall of 1981, portions of a reclaimed area were either interseeded or chisel plowed and reseeded. By 1984, the interseeded area showed 180 plants/m^2, compared with 53 desirable plants/m^2 on the area chisel plowed and then reseeded (Bridger Coal Co. 1984). Interseeding can also be useful as it provides a second age group of plants within the community.

Broadcast seeding has had limited success at Bridger Coal, primarily because of wind erosion. Broadcast seeding is intended to provide the shallow planting depth necessary for native species, as well as improving reclamation esthetically by eliminating the appearance of drill rows. A modified broadcast seeder was used in 1981 on 150 acres. Average first year seedling density resulting from the broadcast seeder was 15.2 seedlings/m^2. Average first year seedling density on 130 acres seeded with a drill in 1981 was 47.5 seedlings/m^2 (Bridger Coal Co. 1984), a 300 percent difference.

Several changes in mulching operations have significantly improved productivity. First, a tubmulcher was purchased to replace a blower type mulcher. The blower was labor intensive, requiring a tractor operator, two hay handlers, and a blower operator. The tractor operator can load the tubgrinder, eliminating the need for three people. Second, (1,500-1,800-pound) square bales are used, eliminating the handling involved with small bales. Third, a 15-foot working width flexible crimper with hydraulically operated gangs and transport wheels was put into service, replacing a small 6-foot crimper. A final improvement in the mulching operation was replacing straw with grass hay. Hay adheres to the surface better, and provides some nitrogen and seed value.

Shrub Establishment

Proposed State regulations require establishment of one shrub per square meter in a mosaic pattern on 10 percent of the mine's reclaimed area. This standard has been met on 48 acres (or 6 percent of reclamation to date) and has nearly been met on several additional areas.

Three varieties of sagebrush, fourwing saltbush (*Atriplex canescens*), Gardner's saltbush (*Atriplex gardneri*), winterfat, rubber rabbitbrush, greasewood, and spiny hopsage (*Grayia spinosa*) are currently used in different seed mixes to promote shrub establishment for wildlife habitat. Fourwing saltbush, Gardner's saltbush, and winterfat have been especially successful in reclamation seedings.

Direct application of soil also maximizes shrub establishment by increasing the survival of propagules that remain in the soil at the surface of reclamation. Wyoming big sagebrush, rubber rabbitbrush, and greasewood have been established with this technique.

Irrigation

A cooperative research project with the University of Wyoming has been initiated to assess the establishment of a predominantly native, diverse seed mix under irrigation. The objectives of the research include determining optimum irrigation rates for initial vegetation establishment; determining optimum seasonal scheduling and duration; and defining interactive effects of varied treatments on initial and ultimate vegetation density, productivity, species composition, and diversity. Preliminary results are available from Bridger Coal and will be presented in the following paper by Mr. Rich Vincent of the University of Wyoming.

Fertilization

Analysis of a poor reclamation area first seeded in 1981 revealed total nitrogen and phosphorous levels (.03 percent N and 2.1 ppm P) below desirable plant available levels (Bridger Coal Co. 1981). Fertilizer at 150 pounds per acre of 18-46-0 was applied in the spring of 1984 and the area was then interseeded. Seedling establishment from the interseeding appears satisfactory and established plant vigor appears improved. However, the utility of fertilizer in this region is probably limited to average or above average precipitation years.

Summary

Many of the initial concerns over reclamation feasibility in a semiarid desert environment have been laid to rest. Improvements have occurred in soil management, shrub establishment, and farming operations. Experiments are underway with various techniques such as irrigation and fertilization.

Wyoming Department of Environmental Quality personnel have evaluated all reclaimed areas at Bridger Coal annually since 1982. The percentage of reclamation rated good or fair increased from 38.3 percent in 1982, to 54 percent in 1983, to 83 percent in 1984. The percentage of disturbance reclaimed has doubled in less than 5 years, from 13.3 percent in 1979 to 27 percent in December 1984. Reclamation has been successfully achieved in areas receiving less than 10 inches of precipitation.

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Design of Temporary Irrigation for Plant Establishment on Arid Coal-Mined Lands in Wyoming

By R.B. Vincent, E.J. DePuit, J.L. Smith, J.A. White, R.E. Paraday, and D. Hartley, University of Wyoming, Laramie, WY

Introduction

Rapid revegetation of mined lands has long been recognized as essential for ultimate reclamation success, for reasons of both initial soil stabilization and retardation of excessive weed infestation (Hodder 1977). Low moisture availability is one of the major factors limiting successful revegetation of arid and semiarid mined lands (May 1975). Supplemental irrigation has often been used to address this problem, particularly on mined lands in the arid Southwest (e.g., Bengson 1977; Aldon et al. 1976; DeRemer and Back 1977; Gould et al. 1975, 1982). Despite the high level of coal mining and prevalence of semiarid to arid conditions in Wyoming, relatively little research on or application of irrigation to mined lands has occurred in this State.

In addition to the climatic constraint of limited water availability, Western revegetation efforts are also commonly impeded by low inherent fertility of "new" mine soils (Bauer et al. 1978). Relief of moisture deficiency through irrigation may allow fertilization to play a more positive role in revegetation efforts.

The specific objectives of this study are to: (1) determine optimum irrigation rates, (2) determine optimum seasonal scheduling and duration of irrigation, (3) define interactive effects of varied irrigation rate and season treatments on vegetation and soils, and (4) define main and interactive effects of varied irrigation rate and season treatments on shrub establishment. A substudy is also being conducted to answer some basic questions concerning fertilization of arid coal-mined lands. The main objective is to evaluate effects of N-P fertilization versus nonfertilization on vegetation and soils under irrigated and nonirrigated conditions.

In addition to the above, a supplemental project was also initiated in 1984, the objectives of which involved (1) a more detailed study of functional relationships between soil water, plant water use and response, salinity, and irrigation treatments; (2) development of general recommendations for the region concerning optimal irrigation methods, and (3) evaluation of the responses of selected soil microbiological parameters to irrigation treatments.

This paper will briefly describe the design of the irrigation project and its current status. Results will be presented in future reports following project completion.

Methods and Design

This study was initiated at the Bridger Coal Mine near Rock Springs in arid southwestern Wyoming. The mine is located on the western edge of the Red Desert and receives between 6 and 8 inches of mean annual precipitation. Four sets of treatments were evaluated: (1) irrigation vs. nonirrigation, (2) five irrigation seasonal patterns/durations, (3) three irrigation rates, and (4) N-P fertilization vs. nonfertilization. These irrigation and fertilization treatments were applied the first year only, and will not be reapplied in following years.

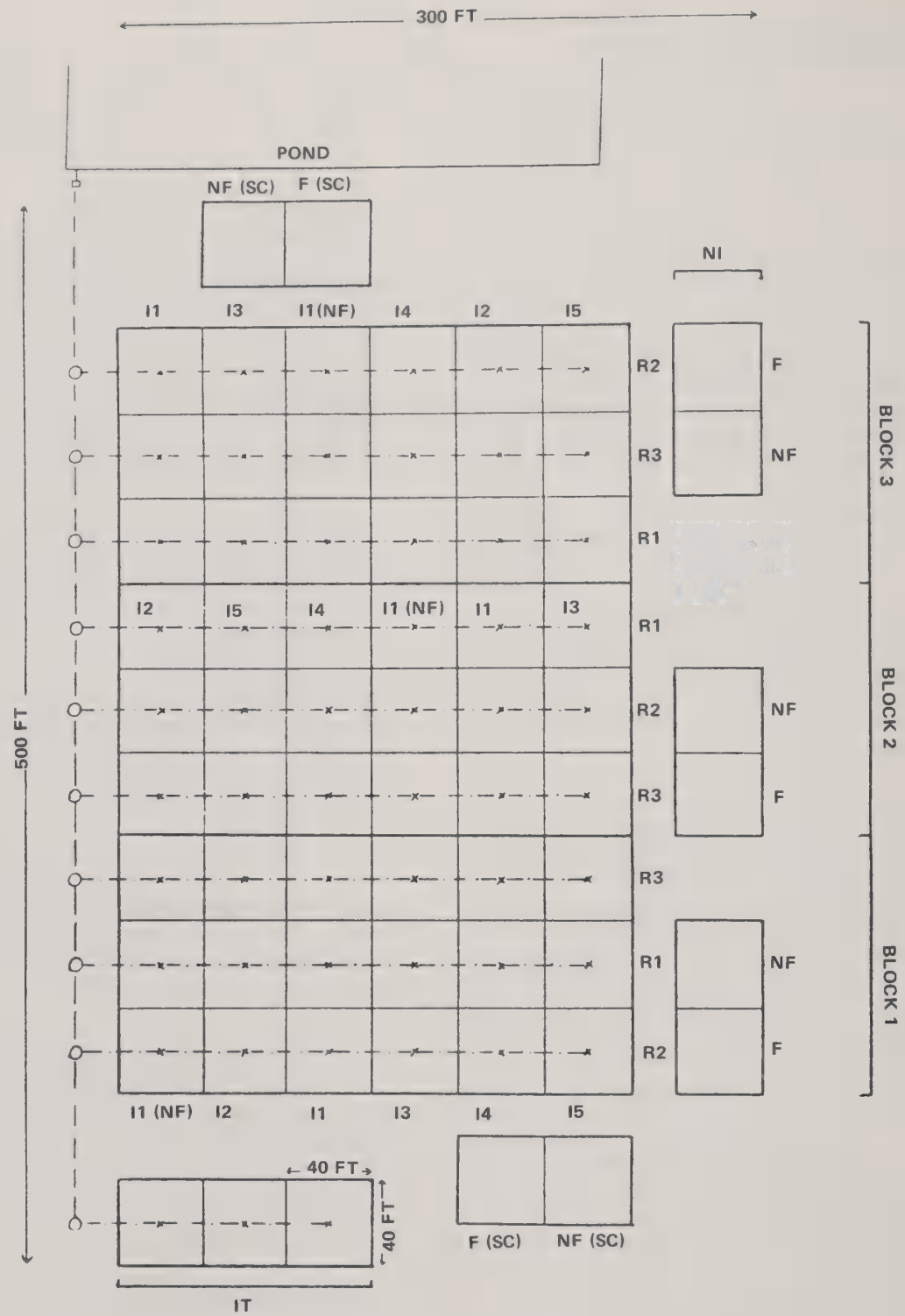
A 3.5A study site was regraded in January 1984 to fairly uniform topography with less than 5 percent slope. Soils were double-ripped to 30 inches, and sequentially covered with approximately 10 inches of subsoil and 6 inches of direct-hauled topsoil.

The seedbed was prepared by chisel plowing and roller harrowing. The site was seeded in early April with a Tye drill. The seed mix applied included 11 cool-season perennial grass, 3 forb and 5 shrub/half shrub species. The site was mulched with wheat straw at 2 tons per acre, which was subsequently crimped into the soil.

Field plots were surveyed and staked to yield smallest experimental units of 40 by 40 feet. All plots designated for fertilization were fertilized in early May by surface application with hand-driven cylcone spreaders. Plots uniformly received 18-46-0 fertilizer at a bulk rate of 250 pounds per acre, yielding rates of 45 pounds actual N/A and 50.6 pounds actual P/A.

Figure 1 presents the field layout of treatment combinations. Three replicate blocks were established, each containing all 20 treatment combinations. Within each block, the irrigation schedule treatments were randomly assigned to columns and the three irrigation rates randomly assigned to lateral rows. One pair of nonirrigated control plots (one fertilized/one nonfertilized) was located 20 feet to the west of the irrigated plot matrix, for each block.

A water storage reservoir was excavated immediately south of the plot matrix and used for holding irrigation water. A Gorman-Rupp engine-driven, self-priming centrifugal pump was installed adjacent to the reservoir. The 6-inch mainline had nine shut-off valves corresponding to each similar irrigation rate lateral and a tee-valve to discharge excess water back to the reservoir.



TREATMENT KEY

Non-Irrigated vs. Irrigated Pattern/Duration
- NI= Non-Irrigated (Control)
- I1= Irrigated May-June-July-August
- I2= Irrigated May-June-July
- I3= Irrigated May-June
- I4= Irrigated May
- I5= Irrigated July-August
- IT= Irrigated Test Plots

Irrigation Rates
- R1= Low (2 inches/month)
- R2= Moderate (3 inches/month)
- R3= Heavy (4 inches/month)

Fertilization
- NF= Non-fertilized
- F= Fertilized
- (SC)= Supplementary Control Plots

Equipment Key
- —·—3-inch diameter irrigation pipe
- — — 6-inch diameter irrigation pipe
- ▫ Pump
- ○ Shutoff valves
- × Sprinkler heads

Figure 1.—Field plot layout of Bridger Coal irrigation study.

Toro Ag-2 series sprinkler heads were selected for this program for reasons of improved uniformity of water distribution and small irrigation radius. An acceptable modification of the AG-2 head was derived which included a low-angle nozzle base, a 00-size spreader nozzle and a 01-size spreader nozzle. The sprinklers were placed on 6-inch risers and located in the geometric center of each plot. Results of distribution and radius tests indicated the greatest uniformity in water application was from 7 to 20 feet, with a total radius of 23 feet at 18-20 psi.

The irrigation program was designed to apply water during three irrigation events per month, each event lasting 2 to 3 days. Irrigation events were separated by 7- to 8-day drying cycles.

Baseline soil sampling was accomplished in early May. Samples were segregated into four depths: 0-2 inches and 2-6 inches (topsoil), 6-16 inches (subsoil), and 16-30 inches (spoil). Samples are currently being analyzed for a comprehensive array of physical and chemical characteristics, with greatest emphasis on fertility and salt status-related parameters.

Soil water content was monitored in both irrigated and nonirrigated plots using gravemetric and neutron activation methods. Soil water sampling was conducted prior to each irrigation event throughout the season. Two lysimeters were also installed and maintained near field capacity throughout the season to measure crop water use and vegetation response to nearly ideal soil water conditions.

Vegetation data were collected in all experimental units for initial plant density in mid-June, canopy cover in late July, peak aboveground biomass in early August, and late season plant density in mid-September. All sampling was restricted to the concentric zone of most uniform water application.

Project Status and Future Activities

All irrigation and fertilization treatments were successfully implemented in 1984, and first year data on soils, soil water, and vegetation response were collected. Presentation and interpretation of data will be deferred to future reports following completion of statistical analysis and collection/analysis of data from subsequent years. Preliminary syntheses of first year data do suggest differential plant and soil responses to irrigation treatments; whether such differences prove significant and/or persistent will be ascertainable only after completion of second year activities.

Second, postirrigation growing season plant and soil data will be collected in 1985, the final year of the first phase of the project. Parameters measured will be the same as in 1984, with the addition of root biomass and distribution. Results from both years will then be synthesized, analyzed and interpreted, and a project final report will be prepared summarizing findings. Hopefully, such findings will be presented at future meetings of VREW.

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A Colorado Regulatory Perspective on Reclamation of Lands Mined for Noncoal Minerals

By Mark S. Loye, Colorado Mined Land Reclamation Division, Denver, CO

The Colorado Mined Land Reclamation Act of 1976 established a statutory framework mandating reclamation of lands mined for noncoal minerals, while allowing for the continued development of mining in Colorado. The seven-member Mined Land Reclamation Board (five of whom are appointed by the governor) includes representatives from the mining industry, agricultural interests, and the environmental community. The Board is the actual decisionmaking body which meets for 2 days each month. After hearing advice from the Mined Land Reclamation Division staff and testimony from the mining industry, the Board considers mining permits and takes other necessary regulatory actions (e.g., reclamation bond releases or enforcement actions against violators). The rules and regulations promulgated by the Board flesh out the framework given in the act.

The Division staff for the Minerals Program consists of seven reclamation specialists and a supervisor (all trained in one or more of the environmental sciences). This staff, in combination with a supporting clerical staff, is responsible for the reviews of permit applications for approximately 200 new mines each year, as well as the ongoing office and field responsibilities for about 1,700 permitted mines. These mines range in size from less than one to several thousand acres. They are surface or underground mines (or a combination of both) which extract nearly every mineral commodity imaginable. The environmental problems associated with the mining and reclamation are varied and complex. The limitations of a small technical staff, given the magnitude of the task, simply do not allow the entire regulatory job to be done as thoroughly as we would prefer.

Interacting with other agencies is one way for the Minerals Section to, in effect, multiply our small work force. Other State agencies such as the Division of Wildlife or the Department of Health supply technical input concerning permitting and enforcement activities. Federal agencies such as the Soil Conservation Service, the Forest Service and the Bureau of Land Management often supply technical input to miners and to our Section staff. Furthermore, our staff must work as closely as possible with Federal land management agencies to assure that mines on Federal lands are properly operated and reclaimed (since mines on Federal lands in Colorado must also be permitted by the State). Cooperative agreements often facilitate this process.

The diversity of mining, as well as the diversity of Colorado ecosystems, generates a vast number of different environmental problems. The most common mine is a dry or wet sand and gravel mine which is to be reclaimed to an agricultural (e.g., grazing) or wildlife (e.g., fish pond) use. Typical problems here include the choice of proper revegetation seed mixtures for the chosen end land use and the necessity of using slope stabilization techniques to ensure the establishment of vegetation. Underground metals mines may present more difficult problems including discharges from portals and reclamation of waste rock dumps. As mines grow very large (e.g., oil shale mines), involve toxic or potentially toxic materials (e.g., cyanide heap leaching for gold or uranium mines), incorporate milling and tailings impoundments, and/or operate in sensitive areas (e.g., placer mines in streams), the diversity of environmental concerns grows, and the solutions to associated environmental problems become much more complex. Reaching concensus on solutions among all parties involved may become very difficult.

Emerging issues for the Minerals Program include the continuing growth in the number of active mines while staffing levels for the Section remain essentially constant; the growing clash between increasing urban sprawl and mining; and the growing number of defaulting mine operators which results in the forfeiture of reclamation bonds by the Board. The Division must make arrangements to reclaim those lands covered by the forfeited reclamation bond monies. The response to these new or continuing problems is first to make the Minerals Program more efficient by prioritization of mines (recognizing that existing staff and resources are not adequate to deal thoroughly with all mines) and increased use of new word and data processing capabilities to automate many office functions. Second, where possible, the Section attempts to foster education of miners in environmentally sound techniques (e.g., safe use of cyanide). The long-term response must be to continue to request more staff from the Colorado State legislature through the annual budget process. The search for other, unique solutions to these emerging problems, is, itself, an ongoing task of the Mined Land Reclamation Board and Division.

Despite the magnitude of the tasks described above, there are several signs that the Minerals Program is succeeding in its mission of reclaiming all lands mined for noncoal minerals in Colorado. Each month, the Board releases several mining operations because reclamation has been successful. Greater control over hazardous mining sites (e.g., cyanide heap leaches for gold) has been achieved as better operational techniques have been developed and used. Furthermore, innovative reclamation techniques are being developed by mining operators (not just in academia) as mines are reclaimed. A consciousness of the need for reclamation and a pride in its accomplishment are developing in much of the mining community. The eventual goal is for mining and reclamation to be integrated into one process. This is a goal that has been proven to be economical for the mining operators and is desired by the environmental community.

Western Reclamation Group Update

By Thomas A. Colbert, Intermountain Soils, Inc.
Denver, CO

Many readers of these VREW proceedings will be interested to know that the Western Reclamation Group (WRG) is alive and active. For those who may not recall, WRG was formed by a small group of dedicated people at the VREW meetings in Tulsa in 1981. These people shared a common concern about problems with regulation of coal mine reclamation under what was then still a relatively new Federal law called the Surface Mining Control and Reclamation Act of 1977.

The early accomplishments of WRG were the identification of current technological issues surrounding Western coal reclamation and of shortcomings inherent in the new regulatory system which sometimes hindered attempts to find or use better methods in reclaiming mined lands. This effort culminated in the presentation of a symposium in Denver in 1983. The proceedings were published in August of that year by the Colorado State University Range Science Department (Science Series No. 35, edited by Edward F. Redente et al.) and are entitled "Symposium on Western Coal Mining Regulatory Issues: Land Use, Revegetation, and Management." Copies of these proceedings are available for $5 from the C.S.U. Range Science Department.

So what is in store for WRG in 1985-1986 and beyond? Under the direction of an 11-member steering committee, two subgroups have been formed. Each subgroup has been assigned the task of identifying current reclamation technical and regulatory issues in two respective groups of States—North Dakota, Wyoming, and Montana; and Colorado, Utah, and New Mexico. These subgroups will solicit papers to be presented at WRG cosponsored program sessions at the annual meetings of the American Society of Surface Mining and Reclamation in Denver, October 8-10, 1985, and the Society for Range Management in Orlando in February 1986.

At this time, four general areas of concern have been identified. Most WRG efforts will probably focus within these areas; (1) determination of overburden quality; (2) characterization and use of topsoil; (3) plant species establishment; (4) reclamation success standards. VREW participants who have interests in Western reclamation and who would like to contribute to the work of the Western Reclamation Group either by working on technical papers or serving on a committee are encouraged to get in touch with one of the steering committee members.

Thermal Plant Control

Bill Davis, *Chairman*

Terra-Torch

By Glen Secrist, BLM, Boise, ID

The need for a ground firing system that is mobile, develops more heat, and is more efficient than conventional propane and diesel/gas torches was first expressed by the Cedar City District BLM in 1983. This need was related through the Utah State Office BLM to the Interagency Equipment Committee. Eventually the request ended up at the Equipment Development Branch of the Boise Interagency Fire Center (BIFC).

BIFC equipment specialists approached helitorch designer Joe Rawitzer in California to develop the first prototype based on the helitorch concept. The original idea was to construct a device that was interchangeable with the Simplex helitorch components using the power system, mixing barrels, and same chassis.

Initially, the prototype exhibited considerable problems with mixing, power, and safety. A BIFC specialist took the original prototype and set out to solve these problems.

Today these problems are basically resolved. The device still employs the Simplex motor which produces 2,000 pounds of instantaneous pressure. This pump is powered by four deep cycle marine batteries wired in parallel to produce 24 volts. A vehicle powered charging device is currently being tested. The chassis has been shortened with a decrease in weight. The entire device weighs about 250 pounds (including batteries) and will easily fit into most pickups.

The hoses (20 to 25 feet) are larger and stronger. The wand has been redesigned to better able the operator to handle it. This wand, which resembles an assault rifle, is equipped with a double trigger device to prevent accidental discharge. A new innovation is the addition of a propane ignition system using small disposable propane bottles attached to the wand, solving earlier ignition problems.

The original concept called for using the same mixing barrels as the helitorch. The oblong shape of the helitorch barrels did not provide sufficient "head" for proper gravity flow of the Alumagel. The redesigned mixing barrels are now square shaped and more upright. A throttling valve controls the flow and to some extent the distance the Alumagel can be fired. A standard solvent is used to clean the barrels, hoses, and wand.

Commercial Alumagel and military surplus M-2 and M-4 fuel thickeners are being used. Obtaining the proper consistency takes considerable experience and skill, since the consistency has a major effect on the flow rate and discharge distance of the material. Safety is always a major concern with incendiary devices. The recent changes made on the wand, ignition, and hoses have greatly improved safety aspects. BIFC is currently training and certifying operators.

There are now two units in the field: one at BLM Rock Springs District and one at the Arizona Strip District at St. George. Demonstrations and tests have been made under a variety of conditions in California, Oregon, New Mexico, and Idaho. Cost of producing the units is running about $5,000. BIFC has several orders to build additional units at the present time.

Field tests indicate that the Terra-Torch is an efficient and cost-effective device for use in fire management where access is limited or where particular burn patterns are desired. The 60- to100-foot arc capability makes burning of slash piles or log decks off steep roads possible. Fuels can be pretreated with the Alumagel, then ignited, producing 20-foot flame heights and generating heat of 2000°F. Two people can blackline an area that would require the efforts of a large crew. Conceivably, costs could be recovered in one or two missions.

Individuals desiring additional information should contact Bob Stroud, Equipment Development Branch, Boise Interagency Fire Center, 3905 Vista Ave., Boise, ID 83705. Telephone either (208) 334-9830 or FTS 554-9830.

Mechanical Plant Control

Gus Juarez, *Chairman*

Mechanical Equipment for Brush Cutting and Slash Treatment

By Dan W. McKenzie, Forest Service, San Dimas, CA

The Forest Service San Dimas Equipment Development Center has prepared an update to the 1978 publication on mechanical equipment for brush cutting and slash treatment titled *Field Equipment for Precommercial Thinning and Slash Treatment.* This update lists current information on mechanical brush cutting and slash treatment equipment. The first section lists mechanical slash equipment and a second section gives criteria to consider when selecting heavy-duty equipment for brush cutting and slash treatment. The third section lists in tabular form, one-line summaries of 75 field projects in which equipment described in the first section was used. All the mechanical equipment except the Madge Rotoclear and the Royer Woodsman are self-propelled, integral prime mover machines. The Rotoclear is towed by a large tractor; the Royer is attached to, and carried by, a standard prime mover such as a wheeled or tracked loader, a crawler, or farm tractor.

Sources of mechanical brush cutting and slash treatment equipment are:

American Ranger Manufacturing, Inc.
1920 American Court
Neenah, WI 54956
(414) 731-0320

The American Ranger Model 300T is a 46,000-pound tracked machine carrying a horizontal shaft head with 60 free-swinging cutters. The unit is powered with a 325-horsepower diesel engine.

Bennington Tractor Co.
706 Alpha Dr.
Cleveland, OH 44143
(216) 449-5816

Bennington has designed and built a horizontal-shaft shredder head with free-swinging blades mounted on a Caterpillar 955 crawler loader undercarriage and powered by a single 210-horsepower engine.

Bombardier, Ltd.
Valcourt, Quebec, Canada J0E 2L0

Bombardier produces a low ground pressure brush cutter with two vertical-shaft cutters powered by a single 130-horsepower engine and using a hydrostatic transmission.

J.I. Case
700 State St.
Racine, WI 53404
(414) 636-6562

J.I. Case adapts a crawler tractor to a brush cutter by equipping the tractor with a hydrostatic transmission and mounting a Royer shredder unit on the front.

Construction Supply, Inc.
10111 West Marginal Way Place South
Seattle, WA 98168
(206) 762-1427

Construction Supply, Inc., markets a machine called the Timbermaster TM-72, formerly known as the Trakmac TM-72 when manufactured by Washington Iron Works. The Timbermaster is a four-tracked, articulated machine with a vertical shaft cutting wheel mounted on a swinging boom that cuts a 12-foot swath.

Construction Supply, Inc., Timbermaster TM-72.

Georgia Pacific Corp.
Machinery Construction Division
Route 10, P.O. Box 566A
Hattiesburg, MS 39401
(601) 268-2300

The Georgia Pacific Corp. has two models of brush cutting and slash treatment equipment available, a tracked mounted biomass harvester and a large rubber-tired horizontal-shaft shredder with fixed teeth powered by a single 600-horsepower engine.

Kershaw Manufacturing Co.
P.O. Drawer 9328
Montgomery, AL 36108
(205) 263-5581

Kershaw has produced five models of its Kershaw Klearway: 10-3, 10-6, 10-7, 10-8, and 10-10, (10-3, 10-6, and 10-7 are no longer in production). All have large rubber tires and two vertical-shaft cutters with free-swinging blades. In the 10-3 the cutters are driven by a single 123-horsepower engine, in the 10-6 and 10-7 by a 180-horsepower engine; and in the 10-8 and 10-10, by a 210-horsepower engine.

Nicholson Manufacturing Co.
3670 Marginal Way South
Seattle, WA 98134
(206) 632-2752

Nicholson Manufacurting has designed and fabricated a large mobile harvester and chipper powered by a 575-horsepower engine and propelled by a hydrostatic transmission. Weight is 72,000 pounds.

Omark Industries, Inc.
Owatonna Division
P.O. Box 568
Owatonna, MN 55060
(507) 451-8654

National Hydro-Ax, Inc., manufacturers of the Hydro-Ax model brush cutters, was acquired by Omark Industries. Omark is continuing to manufacture and market the brush cutters under the Hydro-Ax name. Five models of the Hydro-Ax are in production (311B, 421B, 520, 720, and 721A). The Model 1000 Hydro-Ax is no longer in production. All models have large rubber tires and a single vertical-shaft cutter head with free-swinging blades. Models are powered by single 88-, 125-, 117-, 185-, and 262-horsepower diesel engines.

Omark Industries Hydro-Ax 720 with timed blades.

Orange Service Co.
P.O. Box 852
Clermont, FL 32711
(904) 394-6124

The Orange Service Co., designed, fabricated, and now operates an experimental wheeled, integral, self-propelled, special design shredder with a horizontal shaft with fixed teeth used to shred citrus prunings and trees.

Pettibone Corp.
Alabama Division
P.O. Box 68
Greenville, AL 36037
(205) 382-3183

Pettibone Alabama Division is marketing a compact brush cutter with rubber tires and two vertical-shaft cutters having free-swinging blades powered by a single 123-horsepower diesel engine. Weight is 15,000 pounds.

Pettibone Michigan Corp.
P.O. Box 368
Barage, MI 49908
(906) 353-6611

Pettibone Michigan Corp. is producting a vertical-shaft, free-swinging blade, wheeled brush cutter powered by a single 168-horsepower engine. This firm also designed and builds a horizontal-shaft (with free-swinging blades) forest residues reduction machine powered by a single 244-horsepower engine.

RFD Worldwide, Inc.
1301 Huntcliff Way
Clinton, MI 39056
(601) 924-1327

RFD Worldwide manufactures and markets an articulated, four-wheel brushcutter with a vertical shaft cutter head with four free-swinging blades with stops. The prime mover is equipped with a hydrostatic transmission. The complete unit weighs 12,000 pounds.

Roscoe Brown Corp.
P.O. Box 48
Lenox, IA 50851
(515) 333-4551

The Roscoe Brown Corp. manufactures a four-wheeled, special design tractor with hydrostatic transmission that can be equipped with a Royer Shredder or front-mounted chipper.

Roscoe Brown Corp. mobile chipper in operation.

Rotoclear Manufacturing, Ltd.
8211 31st St. SE
Calgary, Alberta, Canada T2C 1H9
(403) 279-7750

The Madge Rotoclear is a large-wheeled, towed unit with fixed teeth on a horizontal shaft. A D-6 size crawler tractor or large-wheeled tractor is used for towing.

Royce Foundry & Machine Co.
158 Pringle St.
Kingston, PA 18704
(717) 287-9624

Royer manufactures four models of a shredder called the Woodsman, formerly offered as the Shred King by Triumph Machinery Co. All models are horizontal-shaft machines with free-swinging cutter blades. One model is self-powered by a 117-horsepower diesel engine designed to be carried by a crawler tractor or end loader. One model is designed to be carried and powered by a Unimog; the third is designed to be carried and powered through a PTO by a tractor with a three-point hitch, and the fourth is designed as an attachment for a prime mover with a hydrostatic PTO.

Forest Service, USDA
Equipment Development Center
444 East Bonita Ave.
San Dimas, CA 91773
(818) 332-6231

The San Dimas Equipment Development Center designed and had fabricated under contract a forestland residues reduction head. The head has been mounted on a Hydro-Ax 1000.

Madge Rotoclear being towed by a crawler tractor.

Madge Rotoclear cutter head with fixed teeth.

SHUR SHAR Corp.
3241 South Parkway Dr.
P.O. Box 2587
Fresno, CA 93745
(209) 268-5541

The SHUR SHAR Corp. manufactures an articulated, four-track, integral self-propelled, slash treatment machine with a vertical shaft carrying a large 70-inch-diameter cutter wheel with fixed teeth.

Wood-Chip Corp. of America
Merrill, WI 54452
(715) 536-3000

Wood-Chip Corp. of America has designed and fabricated an experimental machine that will grasp a tree, shear it, move it to chipper, and chip it.

Field equipment selection criteria for mechanical brush cutting and slash treatment equipment are:

Vertical vs. Horizontal-Shaft Reduction Heads
A vertical-shaft reduction head has its main shaft in a vertical position (like a rotary lawn mower), and a horizontal-shaft reduction head has its main shaft horizontal to the ground (like a reel lawn mower).

Most vertical-shaft machines have higher kinetic energy levels in their blades than exist in the blades of a typical horizontal-shaft machine.

From field observations, horizontal-shaft machines appear to be safer because they do not tend to throw material, including blades, in all directions in a horizontal plane. Thrown material is not only a serious safety hazard to personnel, but also can damage leaved trees. Horizontal-shaft machines generally have either large bearings per weight of blade or two bearings for each blade.

Fixed vs. Free-Swinging Cutters
Reduction heads can have cutters (teeth, blades, or flails) that are fixed or free-swinging. A fixed-tooth reduction head has cutters that are fixed in relation to the main shaft. A reduction head with free-swinging cutter has blades or flails that can move or swing in relation to the main shaft. Most equipment now has free-swinging cutters. Fixed-teeth cutters work where there is no rock; when the ground is rocky, reports indicate that the free-swinging cutter works better. Also, reports indicate that fixed-tooth cutters run slower, require less power than free-swinging cutters, and can cut down large trees and reduce large stumps to ground level or below.

A free-swinging blade or flail should be timed so that after striking an object it extends out again ready for another impact after one revolution of the reduction head. How this timing can be obtained is outside the scope of this report; however, information on blade or flail timing is available from the Development Center at San Dimas.

SHUR SHAR 20 four-track articulated machine.

Cutter head of SHUR SHAR 20.

Of all the heads with free-swinging cutters, only three have designs that attempt to time the blade or flail: the SDEDC Forestland Residues Machine, the Pettibone Slash-Master PM-900, and the Hydro-Ax with short blades.

Integral, Self-Propelled, Special Design vs. Attachment-Type or Towed Machines
When selecting heavy-duty field equipment for large (50+ acres) precommerical thinning, brush cutting, or slash treatment projects, an integral, self-propelled, special design machine should be given primary consideration over an attachment or a towed machine. Integral, self-propelled, special design machines usually possess more desirable features than can be obtained from an attachment-type or towed machine. These include single engine, good operator position, and maneuverability and agility. However, if a prime mover is already available, an attachment-type or towed slash treatment tool may be the most economical approach on small plots needing total treatment (such as campgrounds and road rights-of-way).

Wheeled vs. Tracked Machines
The nature of the area to be treated dictates whether a wheeled or tracked vehicle is best. Wheeled or rubber-tired vehicles exert more ground pressure than tracked vehicles and generally cannot operate on as steep a slope. The maximum slope for wheeled vehicles is in the range of 15 to 20 percent; for tracked vehicles, 30 to 35 percent.

Wheeled vehicles are usually not as maneuverable as tracked vehicles since they cannot turn in their own length. Tracked vehicles can generally operate under more severe conditions than wheeled vehicles. However, if the area lends itself to wheeled-vehicle operation, wheeled vehicles are usually more economical.

Also, where an area does lend itself to wheeled vehicles, they do not disturb the surface as much as tracked vehicles. Wheeled vehicles generally require less maintenance and, therefore, cost less to operate and also can be moved between job sites under their own power (at speeds up to 15 mph on roads).

A Single Engine and Effective Transmission
Well-designed prime movers for brush cutting, precommercial thinning, and slash treatment equipment should have a single engine with adequate power for both the vehicle's drive and the treatment tool. This minimizes vehicle weight and size while providing maximum power to propel the vehicle and power the treatment tool. With a single engine, the vehicle must have a transmission that can deliver almost full power to the treatment tool while propelling the vehicle at required operating speeds, which can be near zero (most difficult) up to 4 mph.

Also, the transmission must be able to propel the vehicle at full speed. This may require that full (or almost full) power be directed to the driving wheels or tracks. A hydrostatic transmission is most often used because of its ability to accomplish this. Hydrostatic transmissions generally incorporate closed-loop hydraulic systems with some designs operating at up to 6,000 psi, using a variable displacement pump, and usually a fixed displacement motor. A hydrostatic transmission allows a single engine to run at maximum revolutions per minute, delivering full power to the working tool while allowing the carrying vehicle travel speed to vary from zero to maximum.

Operator's Position
The position of the machine's operator is an important consideration. To protect the operator from dust, the cab should be enclosed and air-conditioned. Also, the operator should have a good view of the immediate area to be worked.

Availability, Reliability, and Maintainability
Availability, in a general sense, is the percentage of time a machine is in an operable state when called upon to perform. Specifically, it is the percent of total scheduled time the machine is able to operate (what percent of the time the machine is not broken). Availability is a function of how reliable its components are, and how easy it is to service the machine—which dictates, in part, the length of time needed to repair a failed machine; i.e., its maintainability.

Reliability is the probability that a machine will perform its intended function for a specified interval under stated conditions (how long between machine break downs). Maintainability is that characteristic of design expressed as the probability that a machine can be repaired within a given period of time (how long it will take to fix a broken machine).

In the severe operating environment faced by brush cutting, precommercial thinning, and slash treatment equipment, failures are to be expected. Equipment should be relatively reliable and be capable of being quickly repaired when failure does occur. Availability, reliability, and maintainability are equally important whether a machine is government owned or is operated under contract. If the equipment is not reliable and maintainable, availability will be low and the cost of operation will be excessive.

Maneuverability and Agility
Brush cutting, precommercial thinning, and slash treatment equipment should be both maneuverable and agile. Maneuverability is the ability of a machine to make a series of changes in direction and position, while agility is the quickness and "grace" with which these changes in direction and position are made.

Machines with horizontal-shaft reduction heads, having an inherently shorter coupling than single, vertical-shaft machines, usually display better maneuverability than the vertical-shaft machines. Tracked vehicles, which in general have shorter turning radii than wheeled vehicles, usually have more maneuverability than wheeled vehicles. Reduced overhangs and light weight contribute to good equipment agility.

A good example of a highly maneuverable machine, which also has good agility, is the John Deere 750 crawler tractor. This machine has two hydrostatic transmissions for propelling—one for each track. This enables the tracks to be counter-rotated, permitting the machine to turn quickly in its own length.

Safety
Implicit in all selection criteria has been the element of safety, especially when considering the reduction head's main shaft. All necessary safety equipment and devices (such as guards, shields, rollover protection, spark arrester, etc.) should be in place and not removed before or during operation. The maximum safe operating slope should be known and the machine should not be operated in areas having steeper slopes. Also, unsafe zones should be known or determined, and during operation, no one should be allowed into these zones.

Chemical Plant Control

Ray Dalen, *Chairman*

There is a continuing need for some type of ground equipment that can be used to broadcast pelleted herbicides at low rates (0.5-1.0 lb/ac) and still provide uniform distribution at reasonable cost. The following report was presented by Robert Gaylord, market planning manager, Elanco Products Co.

Dry Herbicide Pellet Application

By Robert Gaylord, Elanco Products Co.,
Flagstaff, AZ

Dry pellets containing root-absorbed herbicides require:

- Uniform application to target plant's root zone.
- Application at a very low density (one pellet per square foot).

Advantages of Aerial Application

- Economical on tracts requiring uniform application and large tracts with long runs.
- Easier to flag in rough terrain.
- Minimum equipment to transport to application site.
- Established aerial applicators usually available.

Advantages of Ground Application

- Selective applications possible on valley bottoms which are productive and hard to apply aerially. Also, where irregular esthetically pleasing patterns are designed to leave wildlife edge and cover, and where productive and nonproductive areas are interspersed.
- Irregular or small tracts.
- Areas far from any landing strip.
- Areas dangerous for aerial application.

Development of equipment capable of precision application has been actively pursued in recent years. To illustrate the present state of the art, the following information is included from Omni Spray, Inc., 905 Washington Ferry Rd., P.O. Box 516, Prattville, AL 36067.

Specifications
Model F1 Forestry Pelleted Material Applicator

- Pneumatically delivers material uniformly over a 90-foot-wide area by means of two opposing hydraulic-driven blower tubes.
- Material feeder rate controlled by electronic ground speed sensor that automatically varies speed of 12-volt dc feeder drive motor.
- Pivoting blower mounting to allow uniform distribution over uneven land up to 20-degree side slope.
- Stainless steel supply hopper—18 cubic feet.
- Hydraulic requirements from carrier vehicle pump—16 gpm at 1,000 psi using 10 hp.
- Weight empty: 1,200 pounds
- Dimensions:
  - mounting base—30 inches length by 38½ inches width
  - overall length with rear guard—81 inches
  - overall width, front (steps not included)—40 inches
  - overall width, rear—76 inches
  - height—58½ inches

Automatic Feeder Control
The controller receives electrical pulses from a drive shaft collar of gear passing near a magnetic pick up. The controller computes these pulse changes into ground speed change and varies the power to the 12-volt dc feeder motor, therefore increasing or descreasing feeder speed as ground speed increases or decreases. With the vehicle stopped and the calibration switch on, material rates per acre can be varied based on 4 mph and the pre-determined swath width. In the automatic position, rates per acre will stay constant if swath width stays constant even though ground speed changes.

Vehicle
Any wheel skidder or crawler tractor vehicle with a minimum of 40 hp and the specified hydraulic capacity.

Performance
Omni states at 5 mph the equipment can cover 40 acres per hour.

Using this rate they estimate an operational cost of $2 per acre application. This does not include move in costs or cost in mounting the spray unit on ground equipment.

Structural Range Improvements

Billy H. Hardman, *Chairman*

Range Structural Equipment Handbook

Each Federal agency involved in range and management has its own structural improvements handbook. In the Forest Service, eight of the nine Regions have their own handbooks. At the Vegetative Rehabilitation and Equipment Workshop (VREW) the participants felt strongly that a national handbook would greatly benefit range managers.

Missoula Equipment Development Center personnel began the project by meeting with members of VREW's Structural Range Improvements Workgroup to outline the handbook. The handbook will consist of four separately bound sections that will be combined into a single manual:

I Fences
- Wire
  - Barbed
  - Smooth
  - Woven
- Wood
- Electrical
- Solar
  - Battery
  - Electrical
- Gates and Cattle Guards

II Other Structures
- Livestock Holding Facilities
- Livestock Bridges and Trails
- Low Water Crossings
- Water Gaps
- Exclosures
- Utility Cage

III Water—Part I
- Pumping Systems
  - Powered
  - Wind
  - Solar
  - Gravity
- Pipe Lines
  - Gravity
  - Powered

IV Water—Part II
- Dams and Reservoirs
- Spring Developments
  - Free Flowing
  - Bog Type
  - Seep Type
- Wells
- Drinking Storage
- Gusslers
- Blown Potholes

Each of the topics in the bound sections will contain the following format:

INTRODUCTION—GENERAL DISCUSSION

- Cost comparisons of different types
- Common problems
- Safety

DEVELOPMENT FEASIBILITY

- Requirements needed
- Cost
- Location
- Site information

DEVELOPMENT OPTIONS

- Layout pattern
- Type of system to be used

CONSTRUCTION AND DESIGN OPTIONS

- Typical Design — Examples With Nomenclature
  - Methods
  - Materials
  - Cost
  - Site impact
  - Life expectancy
- Special Design
  - Obtain advice of engineering or qualified individual

TYPICAL CONSTRUCTION PROCEDURES

TYPICAL CONSTRUCTION PROBLEMS

TYPICAL MAINTENANCE PROBLEMS

Sheep Bridge on a Budget

By Paul J. Butler, Forest Service,
Twin Falls, ID

Cost-efficient range improvement structures are a must in these days of low livestock prices and high material costs.

During the mid seventies, the original Rock Creek sheep bridge was constructed using five native lodgepole pines as bridge stringers. The logs were wired together and keyed into the bank. Prior to each use of the bridge, soil was spread over the top filling voids which prevented sheep from getting stuck between the logs. This structure was very cost efficient, but marginal in design and safety.

In 1983 when we determined the Rock Creek sheep bridge would have to be replaced, we settled on a conventional bridge design using 36-foot steel bridge stringers and a center support. To hold down costs, we shopped around for a best buy on the two steel "I" beams which were 6 inches high, 4 inches wide, and 16 pounds per foot, as well as the prefabricated steel parts as lateral braces, center supports, bolts, etc. The wooden decking, abutment material, and railing were obtained from salvaged materials. All materials were pressure treated when new.

Abutments for both sides of the creek were made from 2- by 12-inch treated planks. The east abutment was trapazoid shaped which, when filled in with rocks and gravel, created a substantial bank anchor. The west side abutment was a lazy "L" shape with the bridge stringers resting on one leg and the other leg supporting the exit trail for the sheep (fig. 1). Anchor planks were also attached to the west abutment perpendicular to each leg and buried 6 feet straight into the bank.

Two center supports (pilings) were installed in the middle of the stream channel to minimize beam deflection. For the support bases we used 18-inch galvanized culverts filled with concrete. Five-foot-long well casing was anchored to the supports. The casing was connected at the top with a 6-inch "I" beam upon which the bridge beams rested freely.

Once the abutments and center supports were completed, the bridge beams were set in place and secured with lateral supports. Four-inch nailing plates were secured to the beams with U-bolts followed by the decking which was nailed in place to allow easy replacement. The railing consisted of ripped scrap 2- by 5-inch planks. All lumber was treated before installation (fig. 2).

The exit area on the west side of the bridge was cleared of brush and opened as much as possible (with bank stability in mind) to encourage sheep movement (fig. 3). In addition, the east entry area railing was set in an opened "V" shape to help funnel sheep onto the bridge (fig. 4).

Figure 1.—West abutment during construction.

Figure 2.—Center supports and railing detail.

Figure 3.—Westside exit area.

Figure 4.—East side exit area of completed bridge.

Costs

Steel stringers	$280.00
Culvert (center supports)	40.00
Concrete	120.00
Misc. steel parts	383.00
Total Parts	$823.00

Other Parts

Decking	Scrap 2" x 12"
Railing	Scrap 2" x 5"
Treated Abutments	Scrap 2" x 12"
Labor	$1,500

Prefabricated Bridge Costs

Bridge	$3,000 - $3,500
Delivery	600
Installation	1,500
Abutments	Extra
Total	$5,100 - $6,000

Cost Comparison

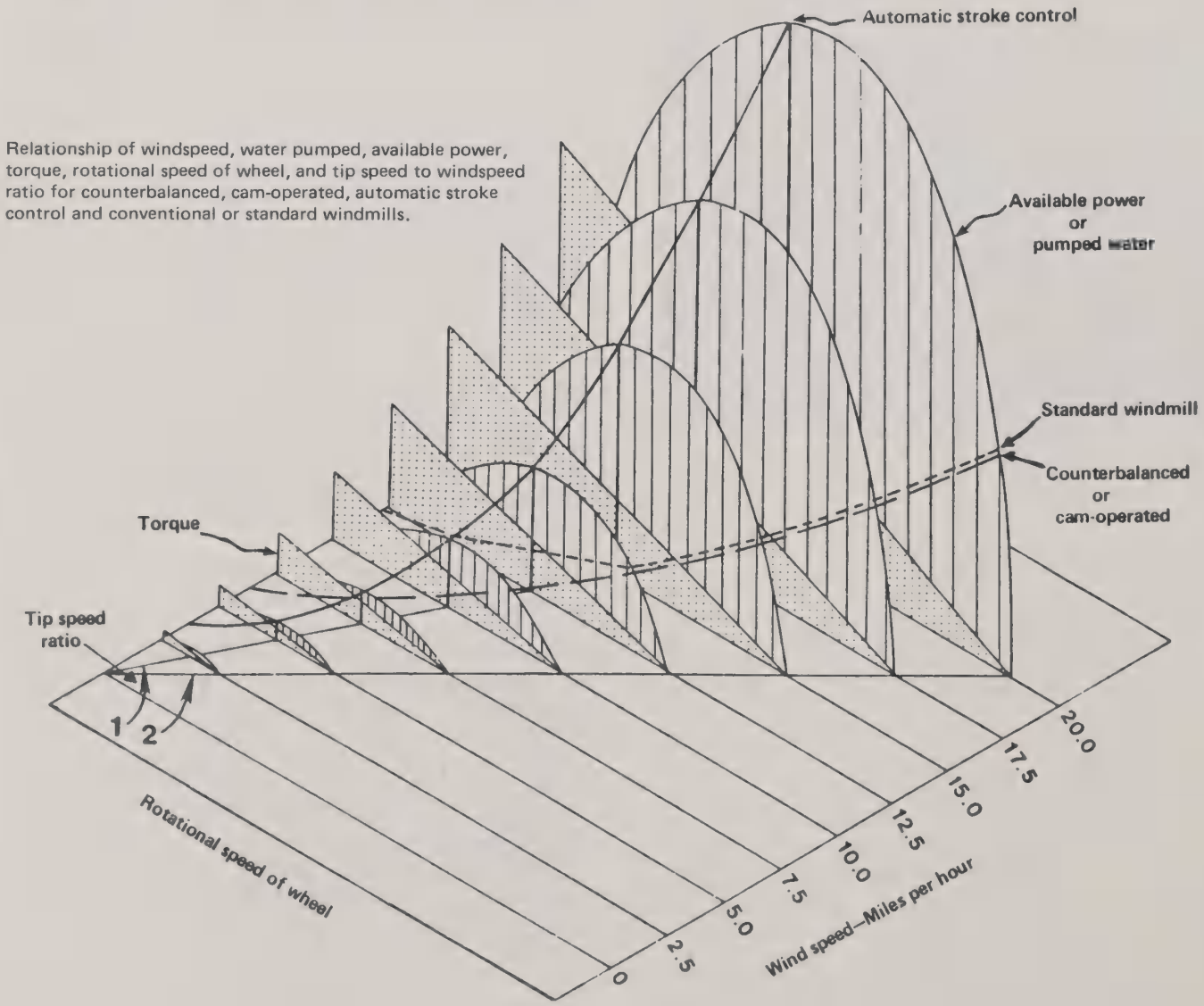
The new Rock Creek sheep bridge cost a total of $2,323 compared to a prefabricated bridge, which costs a minimum of $5,100 to $6,000.

Range Water Systems Improvements
Improved or New Windmills Update

By Dan W. McKenzie, Forest Service,
San Dimas, CA

In last year's VREW report on improved and new windmills—fully counterbalanced, spring-counterbalanced, cam-operated, automatic stroke control, and conventional or standard windmills—were discussed. Since then, a three-dimensional diagram showing the relationship of windspeed, water pumped, available power, torque, rotational speed of wheel, and tip speed to windspeed ratio for these windmills has been developed and is presented below.

Explanation: The power in the wind is approximately proportional to the cube of the windspeed. Torque of a windmill is approximately proportional to windspeed squared. Torque output of a multibladed windmill is highest when the windmill is stopped or stalled. The torque output is zero when the windmill is running at a tip speed, approximately two times windspeed. Maximum power of a multibladed windmill is approximately two times windspeed. Maximum power of a multibladed windmill is approximately at a tip speed to windspeed ratio of 1. Rod and cylinder pumps used on conventional windmills operate at constant average torque. The starting torque required to start a conventional windmill is four to five times the constant average running torque. When operating, the conventional windmill always operates at the constant average torque, because of the flywheel effect of the windmill wheel, and because the windmill cylinder is a positive displacement pump. When a windmill is counterbalanced or cam-operated, the starting torque is reduced so the windmill will start at a lower windspeed. When an automatic stroke control is used, the length of the stroke is changed proportional to windspeed squared, which results in water being pumped approximately proportional to windspeed cubed, the same as the energy level in the wind. Also, with automatic stroke control, starting torque is reduced, allowing the windmill to start at low windspeeds.



Relationship of windspeed, water pumped, available power, torque, rotational speed of wheel, and tip speed to windspeed ratio for counterbalanced, cam-operated, automatic stroke control and conventional or standard windmills.

Fence Failures at Dog Legs and What to do About Them

By Dan W. McKenzie, Forest Service, San Dimas, CA; and
Bret Eisiminger, KIWI Fence Systems, Inc., Waynesburg, PA

Fence failues or post pullout at dog legs (small change of fence alignment) is well known to anyone who installs or repairs fencing (fig. 1). Standard barbed wire fence failures at dog legs are not as critical as with high-tensile smooth wire fencing, which requires the complete fence to be maintained at the proper tension to be effective.

Before a solution to the fence failures or post pull out problem at dog legs is presented, the reason for the problem should be understood.

Fence strainers (braces) generally fail for one of three reasons: (1) structural failure; (2) soil movement or failure; or (3) corner or end post pullout.

Structural failure of a fence end strainer is usually due to improper design, poorly selected material, or overstressed members. By carefully designing fence strainers, and properly proportioning and sizing the members, structural failures of fence strainers should all but be eliminated.

Soil failures of fence strainers are when the soil is so weak that it cannot support the load placed on the soil by the fence strainer and the fence strainer moves through the soil. These soil failures usually can be eliminated by improvements in the design of the fence strainers, such as using larger and/or longer posts or applying plates that have larger areas to bear against the soil.

Corner post pullout of fence strainers is when the corner post lifts out of the ground. These corner post fence failures can generally be eliminated by using longer fence strainers, and/or by placing cleats on the post to increase the coefficient of friction between the post and the soil in order to prevent a pullout-type failure. The pullout-type failure is related to the coefficient of friction between the fence post and the ground. *Above some critical length of a fence strainer, corner or end, post pullout will not occur.* The reason for this critical length is that the fence post bears against the ground; and because it bears against the ground, a vertical force resisting pullout can be generated, but is limited to a maximum of the horizontal force bearing against the post by the ground times the coefficient of friction (about 0.1 to 0.5) between the fence corner post and ground. If the force trying to pull the post out of the ground is greater than the force which can be generated, the post will pullout. By doubling the length of the strainer, the force trying to pull the post out of the ground will be reduced by one half. If the force trying to pull the post out of the ground is below the maximum force that can be generated resisting pullout, the strainer will not fail by pullout. In any fence strainer, this critical length can vary depending on the moisture condition of the soil which affects the coefficient of friction between the fence post and the soil. Generally, as the soil moisture increases, the coefficient of friction decreases. When this happens the coefficient of friction decrease may result in the critical length of the fence strainer increasing above the actual length of the strainer resulting in the corner or end post pulling out.

Figure 1.—Fence failure at dog leg.

Pullout is generally the reason why fences fail at dog legs. Dog legs are small changes in the fence alignment—up to, say, 60 degrees. Small angle changes are the most difficult to hold and are where the most pullouts are seen.

In a dog leg there is an equal pull on the corner post, along each alignment, which results in a force bisecting the dog leg angle and is much smaller than the two equal forces (fig. 2). The effective strainer assembly length is also shorter than either strainer in alignment with the fence. If this effective strainer assembly length is below the critical length, the fence will fail by pullout.

At a dog leg of 60 degrees, the resultant effective length of the strainer assembly is equal to the length of the strainers in alignment with the fence (fig. 3). If the strainers are longer than the critical length, pullout will not occur.

At 90-degree corners, the resultant effective length of the strainer assembly is about 50 percent greater than the strainers in alignment with the fence (fig. 4).

When a fence corner is less than 90 degrees, the resultant effective length of strainer assembly becomes much greater than the strainers in alignment with the fence (fig. 5).

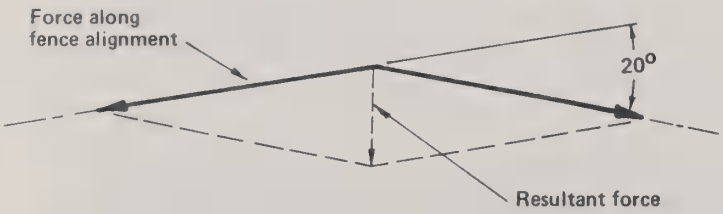


Figure 2.—Forces and resultant force at a 20-degree dog leg. The resultant force and the resultant strainer assembly length are much smaller than the forces and strainer assembly lengths in alignment with the fence.

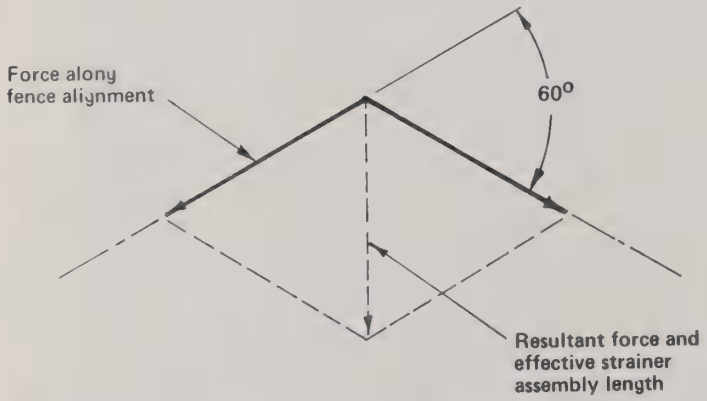


Figure 3.—At a 60-degree change in fence alignment, the resultant force and effective strainer assembly length are equal to the forces and strainers in the alignment of the fence.

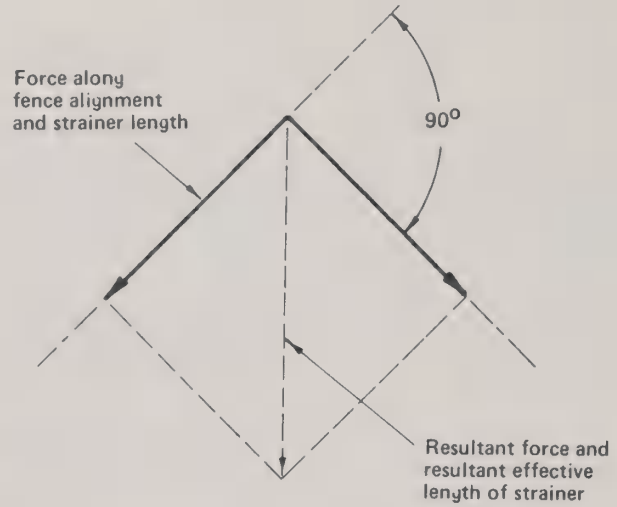


Figure 4.—At a 90-degree corner, the resultant force and the resultant effective length of the strainer are about 50 percent greater than the strainer assemblies in alignment with the fence.

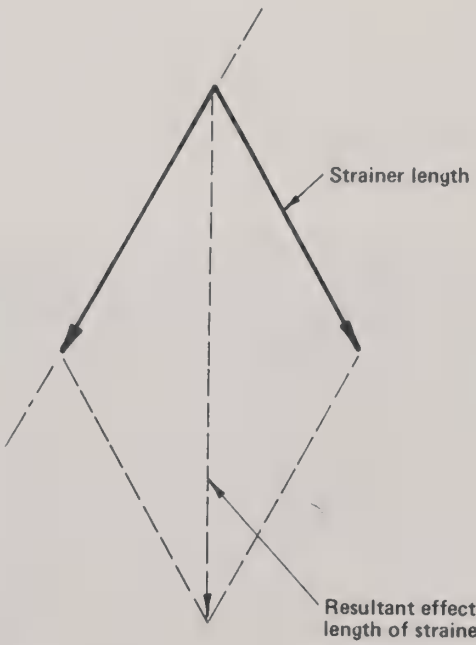


Figure 5.—When the fence corner is less than 90 degrees, the resultant force and resultant effective length of the strainer assembly become much greater than the strainers in alignment with the fence.

Getting back to the problem of what to do about fence failures at dog legs, the thing to do is to make the effective length of the strainer greater than the critical length of the strainer. This can be done by actually placing a strainer in the bisect of the angle of the dog leg, which is longer than the critical length of the strainer (fig. 6). A horizontal strainer can also be used (fig. 7), but the easiest to install and lowest cost strainer is a diagonal strainer as shown in figure 6.

The diagonal strainer is equal in strength and holding force to a horizontal strainer. *Important: When installing a strainer, make it as long as possible for best holding. When using a diagonal strainer, do not block the end of the diagonal on the ground by a stake or post.* Be sure that the diagonal end on the ground is free to move in the direction the diagonal is pointing.

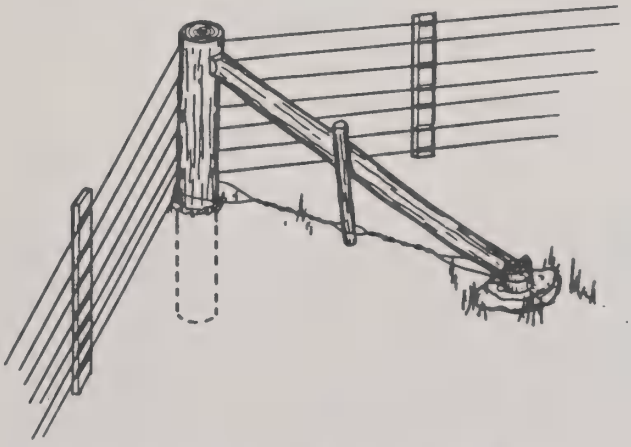


Figure 6.—The use of one diagonal strainer for corner brace in a dog leg.

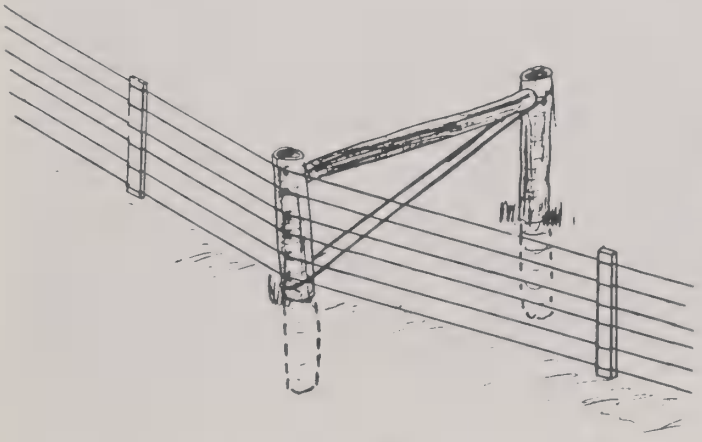


Figure 7.—Horizontal strainer bisecting the angle of a dog leg.

Other methods can and have been used to make the effective length of the strainer greater than the critical length at a dog leg. Methods that have been used are: (1) Ending the fence with an end or gate strainer and starting in the new direction, also with an end or gate strainer (fig. 8); (2) installing four or six panel strainer assemblies in order to increase the effective length beyond the critical length (fig. 9); and, (3) installing a deadman anchor tie back as shown in figure 10. These methods do work, but are generally more costly to install than a single diagonal strainer. Also, a single diagonal strainer is easy to install and works very well in repairing or correcting an impending fence post pullout problem at a dog leg.

In summary, fence failures at dog legs (alignment changes of less than 60 degrees) are caused by the resultant effective strainer length being less than the critical length (6 to 8 feet, but may be as long as 10 feet for a 4-foot fence). The pullout problem at dog legs can be eliminated by placing a diagonal strainer bisecting the dog leg angle with an actual length greater than the critical length. If the dog leg is 60 degrees or less, use a single strainer bisecting the dog leg angle (fig. 11). If the fence change of direction is greater than 60 degrees, either a single strainer or two strainers can be used.

Figure 8.—Fence failures at dog legs can be eliminated by ending the fence with an end or gate strainer and starting in the new direction with an end or gate strainer. Either a horizontal or diagonal strainer can be used, for both are equal in strength and holding force.

Figure 9.—Using a six panel strainer assembly to increase the effective length of a strainer beyond the critical length at a dog leg.

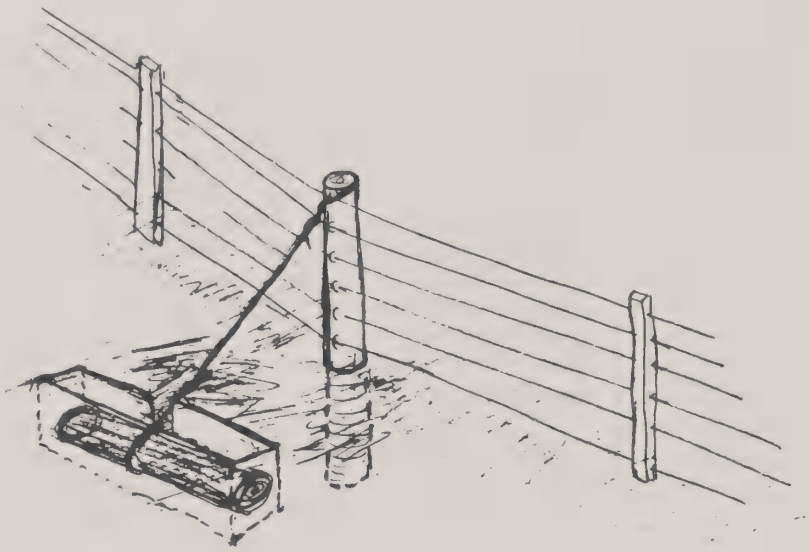


Figure 10.—Deadman anchor tie back prevents fence post pullout at a dog leg.

Figure 11.—Diagonal strainer in use at a dog leg.

Invited Speakers

High-Altitude Aerial Photography

Jimmy R. Bell, Soil Conservation Service (assigned to Forest Service Nationwide Forestry Applications Program), Houston, TX

Introduction

The Agricultural and Resources Inventory Surveys through Aerospace Remote Sensing (AgRISTARS) Program was initiated in 1980. The Program goal is to determine the usefulness, cost, and extent to which aerospace remote sensing data can be integrated into existing and future USDA systems to improve the objectivity, reliability, timeliness, and adequacy of information required to carry out USDA missions.

One of our major efforts has been to improve the capability of using high-altitude photography for applications in resource management. These applications primarily deal with the use of color infrared (CIR) aerial photography.

CIR film is recommended for aerial photography taken for general forest and range applications. When compared with regular black and white or natural film, CIR film has three advantages that make it the best and most useful film for analysis and exploitation of high-altitude photography:

- CIR penetrates haze well because the longer visible and IR wavelengths are less subject to scattering than are the shorter wavelengths of the visible spectrum. A yellow Wratten 12 or orange Wratten 12, "G", filter is used with IR film to remove short wavelength blue light, which aids in haze penetration.
- CIR provides greater target-to-background contrast because of the higher reflectance of IR energy from vegetation in comparison to background objects; i.e., soil, rock, etc.
- CIR provides greater total brightness of vegetation because of high IR reflectance from living vegetation.

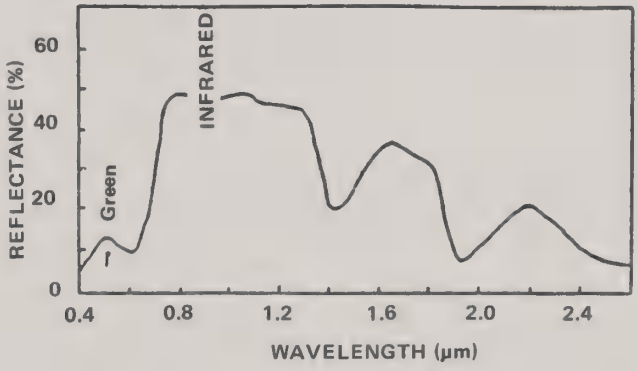
CIR film is sensitive to reflectance of light in the visible and near infrared (400-900 nanometers (nm)) portions of the spectrum, and it is widely used in aerial and space photographic surveys for land use and vegetation analysis. We are all aware that living vegetation reflects light in the green portion of the visible spectrum to which the human eye is sensitive, however, it reflects up to 10 times as much in the near infrared (700-1100 nm) portion of the spectrum, which is just beyond the range of human vision. As a result, when there is a decrease in photosynthesis in plants, whether caused by normal maturation or stress, there is a corresponding decrease in near infrared reflectance. Living or healthy vegetation appears as various hues of red and magenta in CIR film. If diseased or stressed, the color response will shift to browns or yellows because of the decrease in near infrared reflectance.

Color and Color Infrared

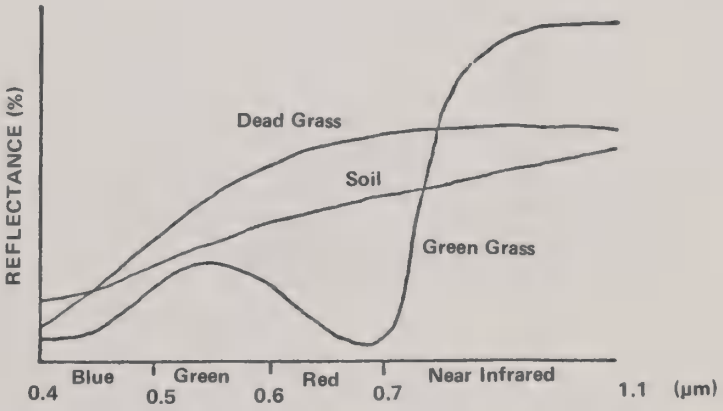
Objects appear to us in color because nature has enabled man to identify scenes and objects by their characteristic color. That is why color aerial photographs are so useful for the collection of information for resource inventory and analysis.

When viewing CIR photography we are looking at objects portrayed with different color relationships. However, when dealing with vegetation and other resources, there are distinct advantages to using CIR. Some of these have been mentioned earlier.

The single most significant shortcoming of CIR film is that many users do not fully understand the relation between color on film and color in nature. To many, the recognition of color is either by rote or by reference to a systematic key (Murtha 1972).



Typical spectral reflectance curves for a green leaf (Adapted from Lillesand and Kiefer, 1979).



Typical reflectance of herbaceous vegetation and soil from 0.4 to 1.1 micrometers (modified from Deering et al., 1975).

A simple review of how color and CIR film works may be helpful. The publication, *Understanding Color Infrared Photography* by William H. Klein is recommended.

Energy in the form of light (incident energy) emitted from the sun is either scattered, absorbed, or reflected. The sensation of seeing colors results from the stimulation of the retina of the eye by light waves of certain lengths. The primary colors of the spectrum are: red, orange, yellow, green, blue, indigo, and violet. The visible region of the spectrum extends from approximately .4 to .75 micrometers. The reflected infrared region extends from about .7 to 1.1 micrometers.

Color and Color Infrared Film

Color and color infrared films are comprised of three emulsion layers, superimposed on each other, on a triacetate base. Each emulsion layer contains dye-forming silver halide compounds that are sensitive to certain portions of the electromagnetic spectrum.

In both color and color infrared film these dye-forming layers become yellow, magenta, and cyan. In color film these layers are sensitized by their complementary colors, blue, green, and red, while in color infrared film these emulsion layers have been chemically shifted (pushed) to a larger wavelength so that the same emulsion layers are sensitized by the green, red, and near-infrared components of the spectrum:

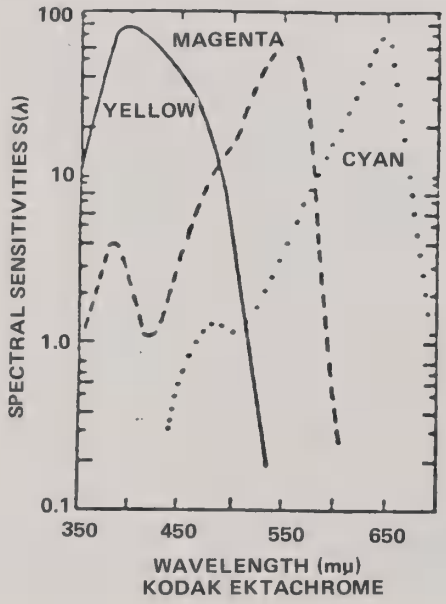
Color film has built into it a filter layer which prevents extraneous blue light from sensitizing the remaining emulsion layers. When using color infrared film for vegetation analysis, blue light is filtered out by putting a yellow (minus blue) filter over or behind the lens of the camera.

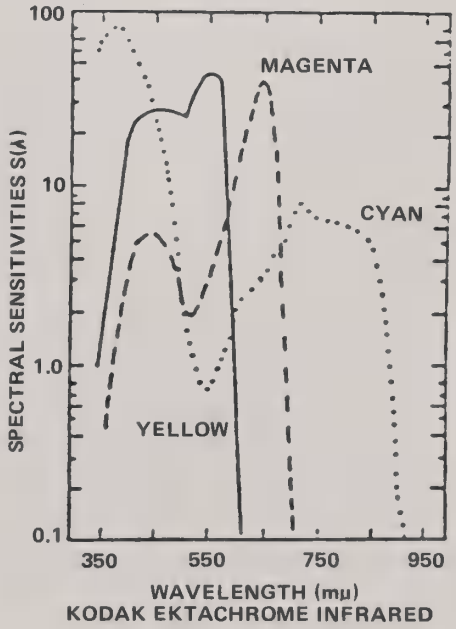
When viewing a positive transparency, the transparency should be regarded as comprised of three complementary color filters (yellow, magenta, and cyan) stacked together, remembering that light filtration is a subtractive process and that filters transmit their own color and block all others. With CIR film, the green sensitized (yellow-forming) layer has been washed out and when viewed over a light table or projected, only blue light gets through because green and red parts of the spectrum have been blocked out by the remaining magenta and cyan layers.

CIR photographs are particularly applicable to many range and forestry problems since green vegetation is highly reflective in the infrared part of the spectrum.

Resource Applications

The major emphasis in the Nationwide Forestry Applications (NFA) Program has been on the applications for using high-altitude photography (flown above 50,000 feet). The use of high-altitude photography has the potential for changing the entire approach to effective resource inventory and analysis.





To do this will require improved skills in the areas of photointerpretation, field data collection, sampling procedures, and decrease in lapse time between reflights and resurveys.

Many people use photography mainly as a map on which they place lines and polygons to locate certain features or delineate certain resource classes. In many instances only a small portion of the data content of the photography is exploited because the user has little training in photointerpretation or the proper equipment to do so.

The amount of information extracted through image interpretation may be jointly affected by photo acquisition system (camera) and human factors; and, successful analysis is directly related to the interpreter's experience with and understanding of the area being studied.

Rangeland Applications

Rangelands are naturally occurring areas of grasses, forbs, shrubs, and open stands of trees. The soil of rangeland ecosystems comprise greater than 40 percent of the Earth's landscape and are recognized as natural grasslands, meadows, tundra, deserts, shrublands, steppes, savannas and woodlands (Williams et al. 1968).

The inventory, monitoring, and analysis of these resources is a major activity in any agency that deals with management of these resources. As agency budgets are cut, it becomes more important to do these jobs more efficiently, e.g., at a cheaper cost and often at a faster rate. The use of remote sensing can be a cost-effective tool for meeting these objectives.

High-altitude photography is one approach that has been cost effective not only for rangeland applications but for other resource applications. Some of the elements that have the potential for being extracted through the interpretation of high-altitude aerial photography are: land cover, biomass, landform, vegetation and condition, e.g., stress mortality, detection of springs, and other areas for potential water development, mapping of manmade features, and monitoring change over time.

It must be understood that neither photointerpretation nor other methods of remote sensing analysis will meet some kinds of data requirements. One example is detailed plant composition data, needed to determine range condition classes. Many of the other requirements for range inventories, however, may be obtained primarily through photointerpretation of high-altitude photography.

Successful image interpretation cannot be done without establishing a correlation between the remotely sensed data and the corresponding features on the ground. The development of a good legend that adequately defines classes to be mapped on the photos is also important.

Because of the current demand for quantitative or statistical statements about the accuracy of data being used by managers, it is recommended that an interpretation accuracy assessment be performed. Even though remote sensing techniques have improved, absolute accuracy may never be obtained. This is partly because of inherent error in interpretation, related to the subjective description of classes and/or categories being identified and delineated. The value of accuracy assessment should be weighed against the cost to obtain the data and the intended use of the end product.

NFA Program Supported Application Projects

Resource Inventory for Land Management Planning—Planning inventory (resource mapping) has been successfully done using Landsat data, panoramic OBC photography, and large format camera (LFC) photography. These projects serve as good illustrations of the application of remote sensing technology. The remote sensing and computer-based vegetation mapping in the San Juan National Forests, CO, is a good demonstration of the use of Landsat for resource inventory (Mazade et al. 1979).

The timber typing on national forest lands with high-altitude LFC photography was done using the Manco Ranger District in the San Juan National Forest, CO (Ward and Eav 1981). The accuracy on this project was 84 percent ± 3.0 percent.

Timber typing in the Tahoe Basin using high-altitude panoramic photography (Ward 1981) demonstrated that timber typing using OBC CIR transparencies can be accomplished with accuracy comparable to current methods being used.

Forest Pest Management

- 1979—panoramic CIR photography was used to assess a mountain pine beetle (*Dendroctonus Ponderosae*) infestation in ponderosa pine (*Pinus ponderosa*) stands on 12 million acres of the Front Range of Colorado (Dillman et al. 1980).
- 1983—Evaluation of High Altitude Panoramic Aerial Photography for Mapping Mortality and Decline of Live Oak (*Quercus virginiana*) in central Texas.
- 1983—Mapping gypsy moth (*Porthetria dispar*) defoliation, Northeastern United States.
- 1983/84—A project is planned to map areas of current outbreak of southern pine beetle (*Dendroctonus frontails*) in the Piney Woods of east Texas using the OBC photography.

Others

- A study was initiated to determine the extent to which riparian areas could be monitored using LFC photography (Bell 1984).
- Monitoring Disturbances and Changes on the San Juan National Forest (Lepoutre 1981).
- 1982 Soil Survey Work, Payette National Forest, ID.
- Accuracy of remotely sensed data: Sampling and Analysis Procedures (Congalton 1982).
- A Computerized Spatial Analysis System for Assessing Wildlife Habitat from Vegetation Maps (Mead 1981).
- The Application of Remote Sensing to Site and Species Specific Wildlife Habitat Analysis (Heinen 1982).
- Development and Evaluation of Methods to Monitor Change on National Forests (Bell 1983).

Exploitation of High Altitude Photography

Many complex and costly instruments are used for photo-interpretation. Equipment is needed for three general purposes: viewing, measuring, and transferring or recording detail to another base.

- Light tables are a must if one is to work with transparency material.
- Stereoscopic viewing equipment is needed if measuring and plotting is to be done.
- Transfer scopes are necessary if large amounts of data are to be transferred from photographs to maps.

Lack of adequate equipment can be a major deterrent to making the maximum use of aerial photographs.

Richards MIM-4 light table with zoom 240 stereoscope.

Richards GLF 30-40 light table and an Old Delft scanning mirror stereoscope.

Equipment Development and Test Funding

Planning and Budgeting Procedure

For many years the "Range Reseeding Committee" was an informal group, meeting each year to exchange information on work of mutual interest and to develop project proposals for work to be done by Equipment Development Centers or field units. The proposals were written, estimated for cost, and finalized "on the spot." Informal but it seemed to work!

Today there are demands being placed on us to plan in detail 2 years in advance, and in general 5 to 10 years ahead. This does take away some of the informality of the operation and dictates the need for a more organized approach to the preparation and submittal of project proposals. Figure 1 shows a plan by which we can meet our budgeting dates. It provides a mechanism whereby the Equipment Development Centers can stay with the budget process of the Forest Service.

The other aspect of our planning procedure is a more uniform format for project proposals. Figure 2 is a suggested guideline for proposals. Following this guide will help all concerned in preparing and reviewing proposals. It should make the flow of information more efficient and provide a much better story for those who must analyze needs, prepare programs, and assign priorities.

We hope that everyone associated with the Vegetative Rehabilitation and Equipment Workshop will cooperate in this more formal approach. It should be an aid to everyone. If any questions arise or there is a need for help in this process, call the Centers or the Washington Office.

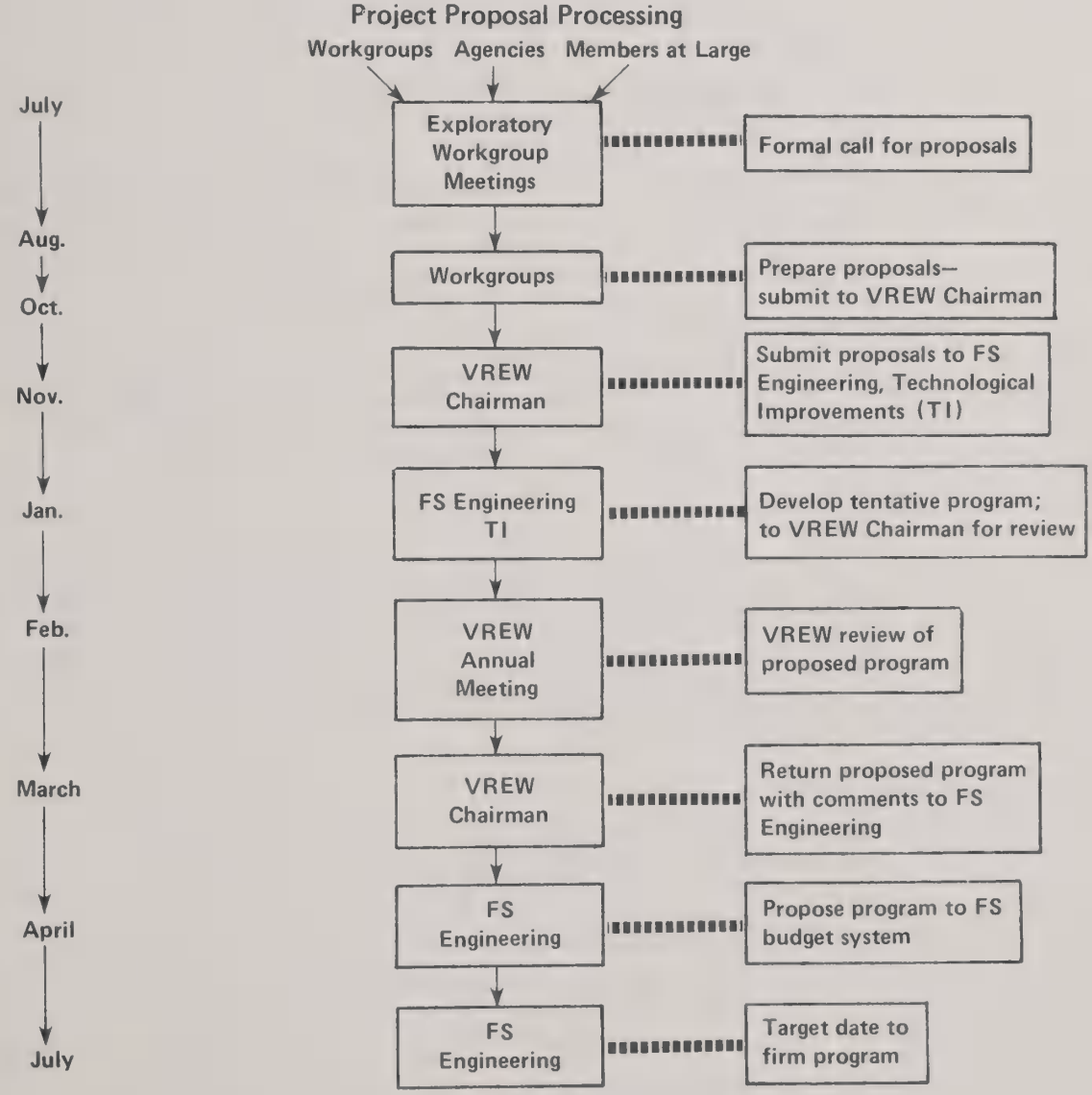


Figure 1.—Project proposal processing.

(PROJECT PROPOSAL FORMAT)

EQUIPMENT DEVELOPMENT AND TEST PROJECT PROPOSAL FOR FY ____

ED&T Project No. (Leave Blank)
Date _____
Primary Interest: _____

_____
(TITLE)

- *(The title should be brief and indicative of project objectives.)*

PROBLEM STATEMENT AND OVERALL OBJECTIVES

- *(State the problem and describe how the work is currently being done. Tell what equipment, materials, or methods are used, and why change or improvement is needed. Show significant advantages and potential savings, such as: increased production or efficiency, property or human hazard reduction, reduced maintenance, and public demand or reaction.)*

- *(State the overall objectives. What is to be accomplished or what is to be achieved by this project?)*

- *(Include amendments to the problem statement and overall objectives, if necessary (for completion by the Development Centers for applicable continuing projects only). The statements of the original problem and objectives should not be changed. If there is a change in emphasis, add revised problem statements and objectives here.)*

SPECIFIC REQUIREMENTS

- *(Distinguish between minimum requirements and those which are desired but not essential. Describe features required or specify performance characteristics. Where more information will be needed but cannot be furnished, list items that should be explored.)*

PRIOR DEVELOPMENT

- *(Briefly describe work already completed or underway which is related to this project. On new projects, this work will generally have been done by other persons or organizations or under other equipment development projects. For a continuing project, tell when it started and briefly state major accomplishments, and actions planned for completion in the current fiscal year. Reference the overall project time frame and total cost estimate if previously made and if applicable, prior reports and publications.)*

PROJECT ORIGIN

- *(Show the name, organization, etc. of persons originating the project and preparing the project proposal.)*

Figure 2.—Format for project proposal.

FY 1985 Program

Missoula Equipment Development Center

Number	*Project*	*Amount*
7E72D22	VREW Information Workgroup Support	$ 24,300
4E42D29	Browse Seed Harvester	20,100
4E42E30	Disk Chain Implement	11,300
5E42D31	Range Structural Equipment Handbook	27,200
5E52D13	Range Improvement Machine	7,500
TE02D15	Technical Services, Range	21,600
		$112,000

Range Publications and Drawings

Below are titles of reports on a variety of range rehabilitation topics, as well as a list of range equipment fabrication drawings. These materials have been produced by the Forest Service Equipment Development Centers at Missoula (MEDC) and San Dimas (SDEDC) and may be of interest to workshop members. Single copies of the reports are available without charge by writing to the appropriate Center. Some drawings are available without cost also; there may be a small charge for others.

Forest Service, USDA
Equipment Development Center
Bldg. 1, Fort Missoula
Missoula, MT 59801

Forest Service, USDA
Equipment Development Center
444 East Bonita Ave.
San Dimas, CA 91773

The list of publications includes *Equip Tips,* concise reports dealing with new equipment, new uses for equipment, and similar topics; *Equipment Development & Test (ED&T) Reports,* documenting major development studies; *Project Records,* describing the technical details of development work, including procedures, results, conclusions, and recommendations; a number of special reports, ASAE papers, and service manuals are listed under "Other Reports."

Equip Tips

Hydraulic Post Puller, Aug. 1984—MEDC

Bitterroot Miniyarder for Light Forest Materials, May 1983—MEDC

Small Yarder for Steep Terrain, May 1981—MEDC

Resource Publications, Dec. 1980—MEDC

Proper Use of Fusees, Feb. 1980—MEDC

Improved Aerial Ignition System, Jan. 1980—MEDC

Protecting Western Conifer Seedlings, May 1979—MEDC

Steep-Slope Seeder for Roadside Slope Revegetation, Feb. 1979—SDEDC

Improved Method for Joining Plastic Pipe, Dec. 1978—MEDC

Seed Dribblers (revision no. 1), July 1977—SDEDC

Spray Boom Assembly, July 1972—SDEDC

Plastic Pipe Laying Machinery, Jan. 1966—SDEDC

Browse Seeder with 20-inch Scalpers, Jan. 1965—SDEDC

ED&T Reports

Catalytic Converter Exhaust System Temperature Tests, Feb. 1977—SDEDC

Slash . . . Equipment and Methods for Treatment and Utilization, April 1975-SDEDC

Clearing, Grubbing, and Disposing of Road Construction Slash, Oct. 1976—SDEDC

Roadside Slope Revegetation, June 1974—SDEDC

Flexible Downdrains, Jan. 1974—SDEDC

Tractor Attachments for Brush, Slash, and Root Removal, Jan. 1971—SDEDC

Results of Field Trials of the Tree Eater, Jan. 1970—SDEDC

Forestland Tree Planter, Sept. 1967—SDEDC

Pine Seed Drill, Sept. 1967—SDEDC

Project Reports

Premo Mark III Aerial Ignition System, April 1985—MEDC

Range Water Pumping Systems—State-of-the-Art-Review, Feb. 1985—SDEDC

Field Equipment for Precommercial Thinning and Slash Treatment, Jan. 1984—SDEDC

Analysis of Spray Deposit Cards Sensitive to Nondyed Sprays, Feb. 1984—MEDC

Preventing Livestock Water from Freezing, Nov. 1983—SDEDC

Rangeland Fencing Systems State-of-the-Art Review, Oct. 1983—SDEDC

Evaluation of the Pettibone Slashmaster Model 900 for Site Preparation in the Lake States, Feb. 1983—SDEDC

Dryland Plug Planter, Dec. 1982—MEDC

Tree-Planting Machine—How Much Can You Afford to Pay for One?, June 1981—SDEDC

Sod Mover Bucket, Dec. 1980—MEDC

Tree/Shrub Planter for Roadside Revegetation, Oct. 1980—SDEDC

Observations on Operations of the Pettibone Hydro-Slasher PM 800, Feb. 1980—SDEDC

Basin Blade for Disturbed Land Revegetation, Nov. 1979—MEDC

Plastic Tubes for Protecting Seedlings from Browsing Wildlife, July 1979—MEDC

Mulching-Tilling Equipment for Soil Conditioning, Jan. 1979—MEDC

Evaluating Methods for Joining Polyethylene Pipe, Dec. 1978—MEDC

A Transplant System for Revegetating Surface Mined Lands, Nov. 1978—MEDC

Grapples for Forest Residues Concentration and Removal, Oct. 1978—SDEDC

Field Equipment for Precommercial Thinning and Slash Treatment, July 1978—SDEDC

Modified Hodder Gouger, Dec. 1977—MEDC

An Investigation of Equipment for Rejuventating Browse, Aug. 1977—MEDC

Survey of High-Production Grass Seed Collectors, Jan. 1977—SDEDC

Remote Sensing for Big Game Counts, Dec. 1976—MEDC

Evaluation of the Vermeer Model TS-44A Tree Spade for Transplanting Trees on Surfaced Mined Land, Feb. 1976—MEDC

Wildlife Habitat Management Needs, Oct. 1975—MEDC

Using Heat for Sagebrush Control, Feb. 1972—MEDC

Other Reports

Low-Cost Diagonal Fence Strainer (ASAE paper No. 84-1624), Dec. 1984—SDEDC

Improved and New Water Pumping Windmills (ASAE paper No. 84-1625), Dec. 1984—SDEDC

38th Annual Report—Vegetative Rehabilitation and Equipment Workshop, Nov. 1984—MEDC

Reclaiming Disturbed Lands, Nov. 1984—MEDC

Manual of Revegetation Techniques, May 1984—MEDC

37th Annual Report—Vegetative Rehabilitation and Equipment Workshop, Oct. 1983—MEDC

Development of a Containerized Shrub Injection Planter Attachment for a Backhoe—A Prospectus, Jan. 1983—SDEDC

Dryland Plug Planter—Operator's Manual, Jan. 1983—MEDC

History of the Vegetative Rehabilitation and Equipment Workshop (VREW) 1946-1981, Dec. 1982—MEDC

36th Annual Report—Vegetative Rehabilitation and Equipment Workshop, Sept. 1982—MEDC

Punch Seeder for Arid and Semiarid Rangelands—A Prospectus, Sept. 1982—SDEDC

Development of A Disk-Chain Implement for Seedbed Preparation on Rangeland—A Prospectus, July 1982—SDEDC

Arid Land Seeder Development—A Prospectus, July 1982—SDEDC

Equipment for Containerized Tree Seedlings, July 1982—MEDC

Catalog for Hand Planting Tools, May 1982 MEDC

Sources of Seed and Planting Stock, Oct. 1981—MEDC

Sod Mover Operator's Manual, Feb. 1981—MEDC

Development of a Rangeland Interseeder for Rocky and Brushy Terrain (ASAE paper 80-1552), Dec. 1980—SDEDC

Equipment for Reforestation and Timber Stand Improvement, Oct. 1980—Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; Request Stock No. 001-001-00563-1; $6.50.

34th Annual Report—Vegetative Rehabilitation and Equipment Workshop, Sept. 1980—MEDC

Modified Basin Blade—Operator's Manual, Mar. 1980—MEDC

Sodder brochure, Mar. 1980—MEDC

Basin Blade brochure, Mar. 1980—MEDC

Mulching-Tilling System brochure, Mar. 1980—MEDC

Transplanting System brochure, Mar. 1980—MEDC

Sprigger brochure, Feb. 1980—MEDC

Dryland Plug Planter brochure, Feb. 1980—MEDC

Revegetation Equipment Catalog, Feb. 1980—MEDC

Agricultural Engineer's Role in Rangeland Improvement and Rehabilitation Equipment (ASAE paper 79-161), Dec. 1979—SDEDC

Observations on Operations of a Residue Shredder and a Brush Harvester, Sept. 1979—SDEDC

33rd Annual Report—Vegetative Rehabilitation and Equipment Workshop, July 1979—MEDC

Front-End Loader Tree Spade—Manual Supplement, Feb. 1979—MEDC

35th Annual Report—Vegetative Rehabilitation and Equipment Workshop, Sept. 1981—MEDC (Available from National Technical Information Service (NTIS) U.S. Department of Commerce, Springfield, VA 22161 for $10.50 in paper and $4.00 in microfiche.)

Concepts—Sod Mover, Aug. 1978—MEDC

Aerial Burning Equipment for Plant Control, Feb. 1977—MEDC

Handbook—Equipment for Reclaiming Strip Mined Land, Feb. 1977—MEDC

Rangeland Drill Operations Handbook, BLM Tech. Note 289, Sept. 1976—SDEDC

Evaluation of the "Vari-Dozer," Feb. 1974—SDEDC

Investigation of Selected Problems in Range Habitat Improvement, Feb. 1974—SDEDC

History—Range Seeding Equipment Committee 1946-1973, Jan. 1974—MEDC

Results: 1972 Range Improvement Survey (27th annual Range Seeding Equipment Committee report), Feb. 1973—MEDC

Implement-Carrying Hitch for Forestry Use (ASAE paper), Dec. 1972—SDEDC

Efficiency and Economy of an Air Curtain Destructor Used for Slash Disposal in the Northwest (ASAE paper), Dec. 1972—SDEDC

Service & Parts Manual for the Contour Furrower Model RM 25, June 1970—SDEDC

Service & Parts Manual for the Brushland Plow, June 1968—SDEDC

Service & Parts Manual for the Rangeland Drill Models PD-10x6 and B-20x6, Aug. 1967—SDEDC

Other Publications of Interest to VREW

Private Water Systems Handbook, Midwest Plan Service, Iowa State University, Ames, IA 50011. $2.50

Water Systems Handbook (7th Edition), Water Systems Council, 221 North La Salle St., Chicago, IL 60601. $6

Water Well Handbook, Keith E. Anderson, Missouri Water Well and Pump Contractors Association, Inc., P.O. Box 517, Belle, MO 65013. $10

Evaluation of Pumps and Motors for Photovoltaic Water Pumping Systems, David Waddington and A. Herievich, Solar Energy Research Institute. Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. $3 microfiche; $5.25 printed copy

Rangeland Drill, reprint from "Rangelands," vol. 4, no. 3, June 1982.

Glossary of Surface Mining and Reclamation Terminology, Bituminous Coal Research, Inc., 350 Hochberg Rd., P.O. Box 278, Monroeville, PA 15146. (412) 327-1600. $2

Range Development and Improvements, 2nd edition, J.F. Vallentine. 1980, Brigham Young University Press, Provo, UT 84602. 545 pp. $18.95.

How to Build Fences with Max-ten 2—High Tensil Fence Wire, U.S. Steel Corp., P.O. Box 86 (C-1424), Pittsburgh, PA 15230. $5 plus $1.50 postage and handling

How to Design An Independent Power System, Terrance D. Paul, Best Energy Systems for Tomorrow, Inc., P.O. Box 280, Necedah, WI 54646, (608) 565-7200. $4.95

From American Association for Vocational Instructional Materials (AAVIM) Engineering Center, Athens, GA 30602:

Planning for an Individual Water System, No. 600, $6.95

Planning Fences, No. 404, $4.25

Building Fences, No. 405, $4.25

(For orders less than $10 add $1 for postage and handling; for orders over $10 add 8 percent for postage and handling.)

Range and Pasture Seeding in the Southern Great Plains, Proceedings of a symposium on the newest grasses, seeding techniques, and seed harvesting/processing equipment, Oct. 19, 1983, Vernon, TX 76384, Texas A&M Univ., Agricultural Research and Extension Center, Vernon, TX, 115 pages, $5.00. Order Seeding Proceedings Attn: Harold Wiedemann, Texas Agricultural Experiment Station, P.O. Box 1658, Vernon, TX 76384

Windmills and Pumps of the Southwest, Dick Hays and Bill Allen, Eakin Press, P.O. Box 23066, Austin, TX 78735, 110 pp. $7.95

Electric Fencing for Rangelands, Special Series 27, Colorado State Univ., Agricultural Experiment Station, Fort Collins, CO. Order from Bulletin Room, Colorado State Univ., Fort Collins, CO 80523, (303) 491-6198, $3.25 post paid

Small-Scale Solar-Powered Pumping System: The Technology, Its Economics and Advancement; main report by Sir William Halcrow and Partners in association with Intermediate Technology Power, Ltd., for the World Bank under project UNDP Project GLO/80/003, June 1983

Farm Show, published bimonthy by Farm Show Publishing, P.O. Box 704, Lakeville, MN 55044, (612) 469-5572, $9.95/year

Drawings at SDEDC

Pipe Harrow, RM1-01 and 02

Brushland Plow, RM2-01 to 22

Oregon Press Seeder Assembly (not complete), RM19-01 to 07

Plastic Pipe Layer Assembly, RM21-01 to 03

Reel for Laying Plastic Pipe, RM24-01

Contour Furrower, RM25-01 to 14

Rangeland Drill Deep Furrowing Arms, RM26-46 to 61

Steep-Slope Seeder, RM33-01 to 18

Demonstration Interseeder for Rocky and Brushy Areas, RM35-01 to 09

Drawings at MEDC

Sprig Spreader, No. 652

Sprig Harvester, No. 651

Dryland Sodder, No. 631

Tubeling Planter, No. 628

Basin Blade, No. 619

Horse Trap Trigger, No. 618

Mulch Spreader, No. 611

Tree Transport Container, No. 604

Tree Transplant Trailer, No. 602

Modified Hodder Gouger, No. 583

Dixie Sager and Modified Ely Chain, No. 568

Incendiary Grenade Dispenser, No. 522

Attendance at Annual Meetings

Meeting			Participants				
Date	*Place*	*Presiding Chairman*	*Federal Gov't*	*State Gov't*	*Private*	*Foreign*	**Total**
Dec 1946	Portland[1]	Joseph F. Pechanec	6	0	0	0	6
Dec 1947	Ogden[1]	" "	9	0	0	0	9
Jan 1949	Denver	" "	15	0	0	0	15
Dec 1949	Ogden[1]	" "	22	0	0	0	22
Jan 1951	Billings	" "	34	5	0	0	39
Jan 1952	Boise	A. C. Hull	45	9	0	0	54
Jan 1953	Albuquerque	"	75	15	9	1	100
Jan 1954	Omaha	"	63	8	3	5	79
Jan 1955	San Jose	W. W. Dresskell	62	10	4	1	77
Jan 1956	Denver	William D. Hurst	86	12	1	2	101
Jan 1957	Great Falls	" "	95	10	4	0	109
Jan 1958	Phoenix	Frank C. Curtis	87	9	3	0	99
Jan 1959	Tulsa	" "	84	5	2	0	91
Jan 1960	Portland	" "	98	10	3	3	114
Jan 1961	Salt Lake City	" "	123	11	14	2	150
Jan 1962	Corpus Christi	Frank Smith	58	5	7	1	71
Jan 1963	Rapid City	" "	52	6	1	0	59
Jan 1964	Wichita	John Forsman	61	10	5	0	76
Jan 1965	Las Vegas	" "	77	8	6	0	91
Feb 1966	New Orleans	" "	47	8	5	1	61
Feb 1967	Seattle	A. B. Evanko	58	10	4	0	72
Feb 1968	Albuquerque	" "	84	16	13	1	114
Feb 1969	Great Falls[1]	" "	46	3	12	0	61
Feb 1970	Denver	" "	81	8	11	0	100
Feb 1971	Reno	" "	74	6	15	2	97
Feb 1972	Wash., D.C.	" "	48	3	6	0	57
Feb 1973	Boise	" "	60	7	7	4	78
Feb 1974	Tucson	Bill F. Currier	61	12	10	14	97
Feb 1975	El Paso[1]	Stan Tixier	49	9	11	1	70
Feb 1976	Omaha	" "	50	17	12	0	79
Feb 1977	Portland	Vern L. Thompson	63	26	31	10	130
Feb 1978	San Antonio	" "	68	26	35	6	135
Feb 1979	Casper	Ted Russell	74	35	72	12	193
Feb 1980	San Diego	" "	97	44	88	21	250
Feb 1981	Tulsa	" "	56	35	111	16	218
Feb 1982	Denver[1]	" "	60	18	68	5	151
Feb 1983	Albuquerque	" "	119	82	96	9	306
Feb 1984	Rapid City	Randall R. Hall	95	22	49	7	173
Feb 1985	Salt Lake City	" "	110	46	85	13	254

[1]Meeting not in conjunction with Society for Range Management meeting.

VREW Organization Membership

Steering Committee

Ray Hall, *Chairman,* FS
P.O. Box 2417
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Dr. Phillip Dittberner, FWS
Fort Collins, CO

Don Pendleton, SCS
Washington, DC

Ralph Nave. ARS
Beltsville, MD

Arlo Dalrymple, OSM
Washington, DC

Sam Miller, BIA
Washington, DC

Paul Andrews, BLM
Washington, DC

Dan Merkle, Ext. Serv.
Washington, DC

Exploratory Committee

The Exploratory Committee is made up of the Steering Committee, workgroup chairmen, and appropriate Equipment Development Center personnel from Missoula and San Dimas.

1985 Workgroups

Persons interested in participating in the activities of a workgroup are encouraged to write or call the workgroup chairman about their interest.

Information and Publications

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*GPO 691 - 905 (1985)